Fire and Life Safety Report

Mayo Clinic Specialties Building

Phoenix, Arizona

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Statement of Disclaimer

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Executive Summary

The MCS Building is a medical clinic facility located in Phoenix, Arizona. It is a four-story building with roughly 40,000 square feet of occupied floor area per story. The MCS Building is connected to an adjoining hospital on all four occupied stories, and is not considered a separate building from the hospital in accordance with the 2012 International Building Code (IBC). However, for the academic purposes of this report, only the fire and life safety features of the MCS Building are discussed, as if it is a separate building. It consists primarily of medical offices and outpatient clinics, and is not used for any inpatient services or other purposes that would cause occupants to be incapable of self-preservation. Construction was completed in 2004, and the building was designed using the 2000 edition of the Phoenix Building Construction Code (PBCC) and Phoenix Fire Code (PFC). These codes are based on the IBC/IFC, with City of Phoenix amendments. However, the fire and life safety analysis of the building in this report is performed using the 2012 edition of the PBCC/PFC.

The prescriptive-based analysis in this report focuses on the structural fire protection, fire suppression systems, fire alarm and detection systems, and egress features of the MCS Building. The analysis demonstrates that the MCS Building is in accordance with all of the requirements of the PBCC for Type I-A construction. The fire suppression systems are installed in the building in accordance with PBCC/PFC requirements, and were designed following the requirements of NFPA 13. There is an automatic fire alarm and detection system as well as an emergency voice/alarm system installed in the MCS Building, in accordance with the PBCC/PFC and NFPA 72. However, candela ratings in Room 2-229 and Room 3-539 should be investigated, and it should be ensured that Room C-201B is provided with visible and audible notification once it is separated from the adjoining office. It should also be ensured that the new linear accelerator rooms are equipped with area smoke detectors. The egress features built into the MCS Building were found to comply with the prescriptive requirements of the PBCC/PFC.

The performance-based analysis in this report investigated the ability of the fire protection systems in the MCS Building to perform satisfactorily in several different fire scenarios. This analysis was completed using the Fire Dynamics Simulator (FDS) program, in conjunction with the Pyrosim graphical user interface and the Pathfinder evacuation simulator. A basic design fire was constructed using data from a NIST workstation fire test, and was situated on each floor of the MCS Building in order to block occupant access to a stairway used for egress. This scenario was applied to each half of the second and third floors, as well as one half of the concourse floor. The properties and location of the fire products and the smoke produced were tracked, along with the relative location of evacuating occupants. For each scenario, it was investigated whether or not tenable conditions were maintained for the occupants during the evacuation process.

The simulations indicated that when tenability is analyzed on this basis, the only concerning scenario was the Southwest Third Floor model. The visibility criterion was violated in the area around occupants queueing for the northeast stairway. However, visibility is not reduced to the point where exit signs near the stairway and horizontal exit are no longer visible. In addition, trained staff is available to facilitate evacuation, and to re-organize queueing so that all occupants are protected by the 2-hour rated horizontal exit wall. For these reasons, this particular violation of the visibility tenability criterion was determined to not be critical with respect to life safety.

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1. Scope of Report

This Fire and Life Safety report will describe in detail the required and provided fire and life safety features of the Mayo Clinic Specialties (MCS) Building. The features discussed will include the structural fire protection, fire suppression system, fire alarm and detection system, and the egress system. Following the discussion of these prescriptive features, a performance-based analysis involving potential fire scenarios will be presented. A summary of both the prescriptive- and performance-based analyses, and their findings, will conclude this report.

The intended function of this report is to provide the owner (or developer), the Authority Having Jurisdiction (AHJ), and the fire department with a resource outlining the design of the fire and life safety systems in the MCS Building. The building will be analyzed in accordance with the following:

- 2012 edition of the Phoenix Building Construction Code (PBCC), based on the 2012 edition of the International Building Code (PBCC)
- 2012 edition of the Phoenix Fire Code (PFC), based on the 2012 edition of the International Fire Code (PFC)
- 2013 edition of NPFA 13, "Standard for the Installation of Sprinkler Systems"
- 2013 edition of NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems"
- 2013 edition of NFPA 72, "National Fire Alarm and Signaling Code"

2. Facility Description

The Mayo Clinic Specialty Building (MCS Building) is an outpatient clinic building connected to the northeast corner of Mayo Clinic Hospital in Phoenix, Arizona. Construction on the building was completed in 2004. The MCS Building consists of a variety of outpatient specialty services and contains offices, exam rooms, labs, and large medical equipment. The building has 3 occupied floors above grade, an unoccupied mechanical penthouse above the 3rd floor, and an occupied below-grade concourse. The MCS Building is connected to the adjoining hospital building on every floor except the penthouse level. This adjoining hospital building contains operating rooms, an emergency room, patient housing, and a full-service clinical laboratory.

A concrete foundational wall surrounds the concourse level of the MCS Building, which has a concrete slab foundation. The above-grade exterior walls are covered with an Exterior Insulation Finishing System (EIFS) over gypsum wallboard, and the primary structure is constructed of steel.

The concourse floor of the MCS Building, which is mostly below-grade, contains a mixture of offices, exam rooms, laboratories, and conference rooms. The main electrical room is on this floor, and the concourse floor also houses a linear accelerator lab. The first floor of the MCS Building primarily includes exam rooms, offices, laboratories, research centers, and conference rooms. The second floor contains additional offices, exam rooms, and research centers. The third floor contains mostly offices and exam rooms. Every floor has a lobby and registration area on the north end.

The basic floor plan for each story of the building is shown in Appendix A.

3. Occupancy Classification According to the PBCC

The southwest corner of the concourse floor of the building is classified as an R-3 Occupancy in accordance with PBCC Section 308.4.1. This area of the concourse houses an in-patient holding area and a High-Dose Rate (HDR) treatment room for cancer patients, who may be incapable of self-preservation. Although five or fewer persons will receive care at a time in this area, it was decided to design to a Group I-2 Occupancy instead. Special detailed requirements for Group I-2 Occupancies are found in PBCC Section 407.

There is a large storage area on the east end of the concourse, and a small linen storage area on the west end of the concourse. The large storage area is used for general storage of goods in cardboard boxes, and is classified as a Group S-1 Occupancy. However, it does not occupy more than 10 percent of the concourse floor area, and serves an ancillary function to the rest of the building. Therefore, it is an accessory occupancy to the rest of the building (PBCC Section 508.2). The linen storage area is an incidental use occupancy in accordance with Table 509 of the 2012 PBCC. Because of this, the linen storage area is included in the Group I-2 Occupancy. A color-coded floor plan of the concourse level is shown below in Figure 1.

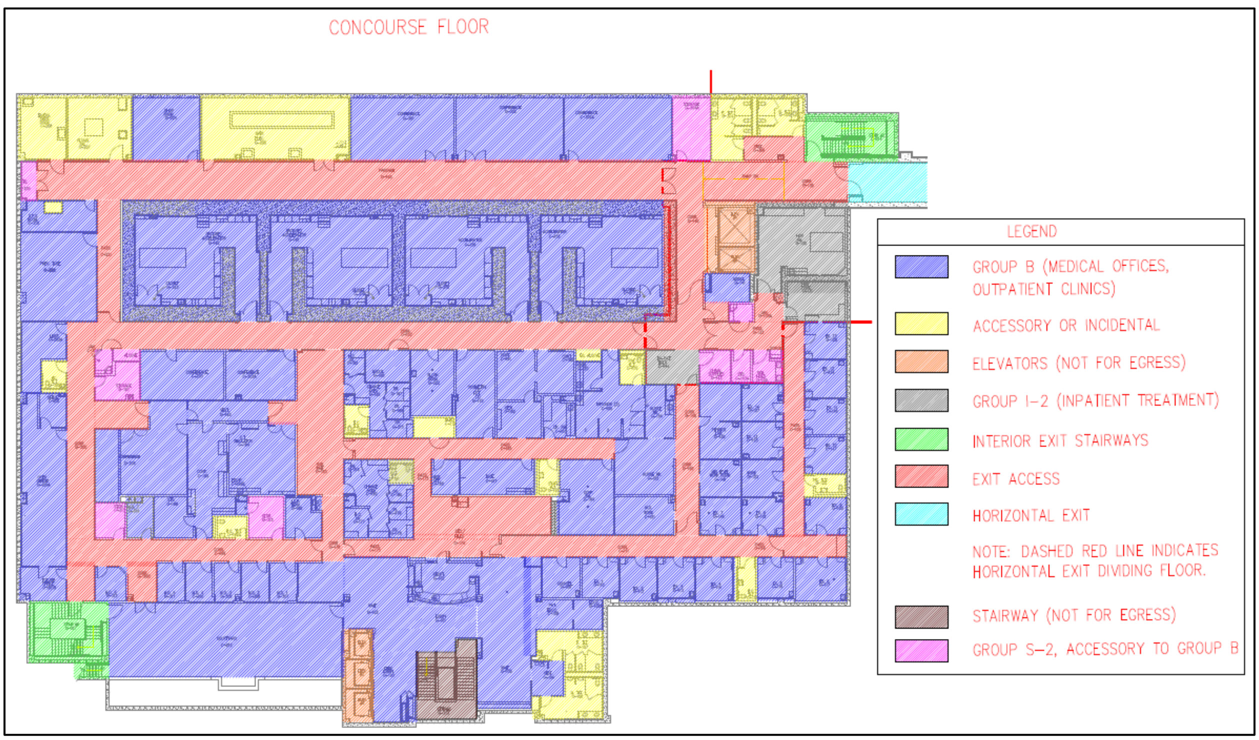

Figure 1. Concourse floor color-coded occupancy classifications

A majority of the rest of the MCS Building is classified as a Group B Occupancy. This is because the various exam rooms (clinic outpatient), offices, conference rooms, and laboratories are all listed as a Group B Occupancy in accordance with Section 304.1 of the 2012 PBCC. According to Section 508.2, accessory occupancies are occupancies which are ancillary to the main occupancy of the building. Because the main occupancy of the MCS Building is Group B, the Group I-2 occupancy in the southwest corner of the building must serve an ancillary function to be considered an accessory occupancy. This area houses in-patient holding and a HDR treatment room, which does not provide service or support for the rest of the building, which is a Group B Occupancy. This means that the Group I-2 Occupancy area cannot be considered an accessory occupancy.

Although most of the MCS Building is classified as Group B Occupancy, there are several spaces scattered throughout the building that are classified differently. There are accessory/incidental spaces (generally restrooms and small electrical/mechanical rooms), as well as Group S-2 small storage spaces. The various occupancy classifications present on the first, second, and third floors are shown in Figure 2, Figure 3, and Figure 4 respectively. Larger versions of these floor plans indicating occupancy classifications are available in Appendix B.

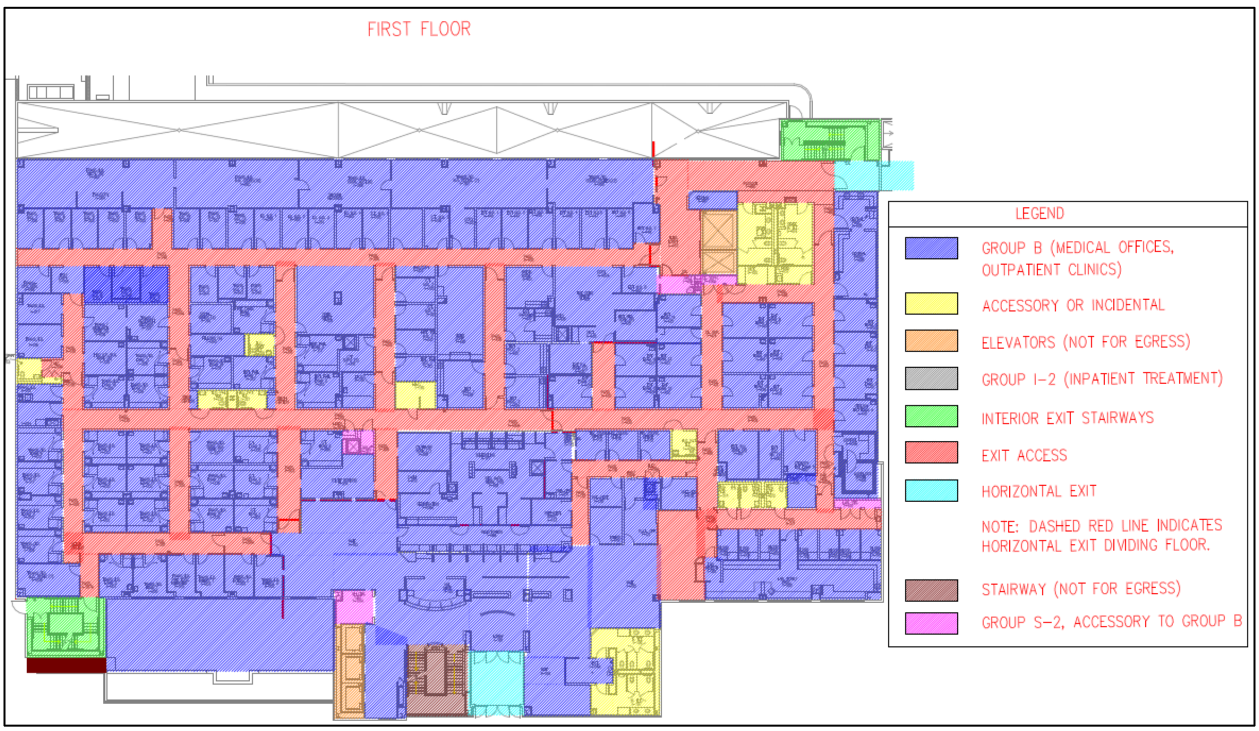

Figure 2. First floor color-coded occupancy classifications

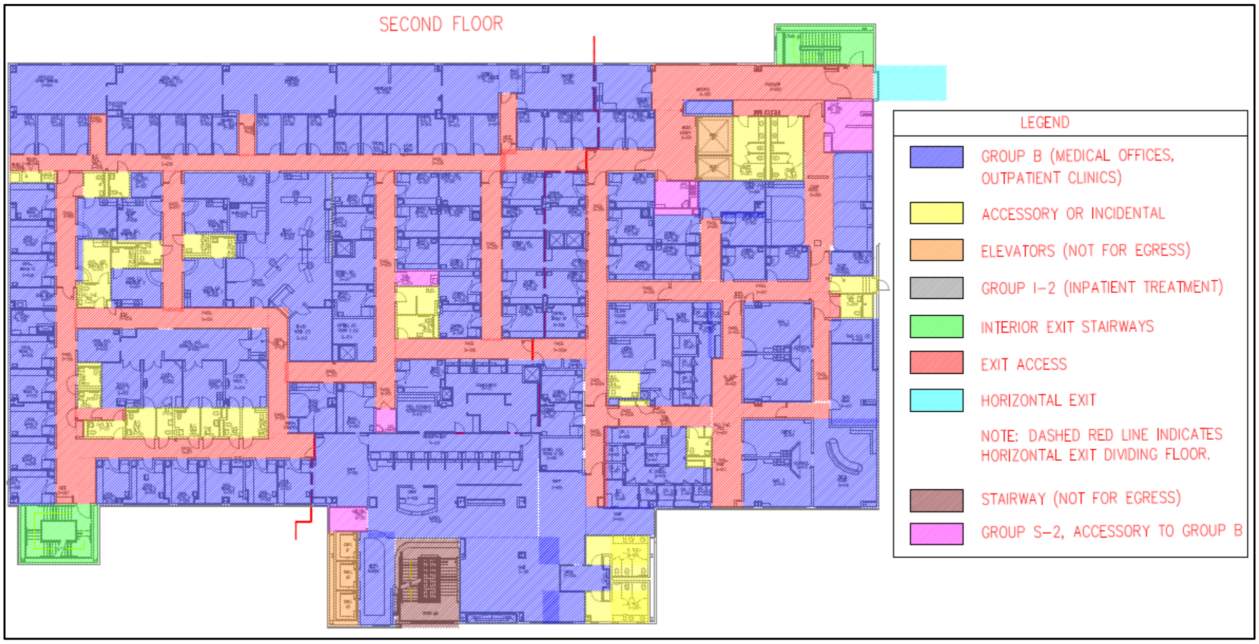

Figure 3. Second floor color-coded occupancy classifications

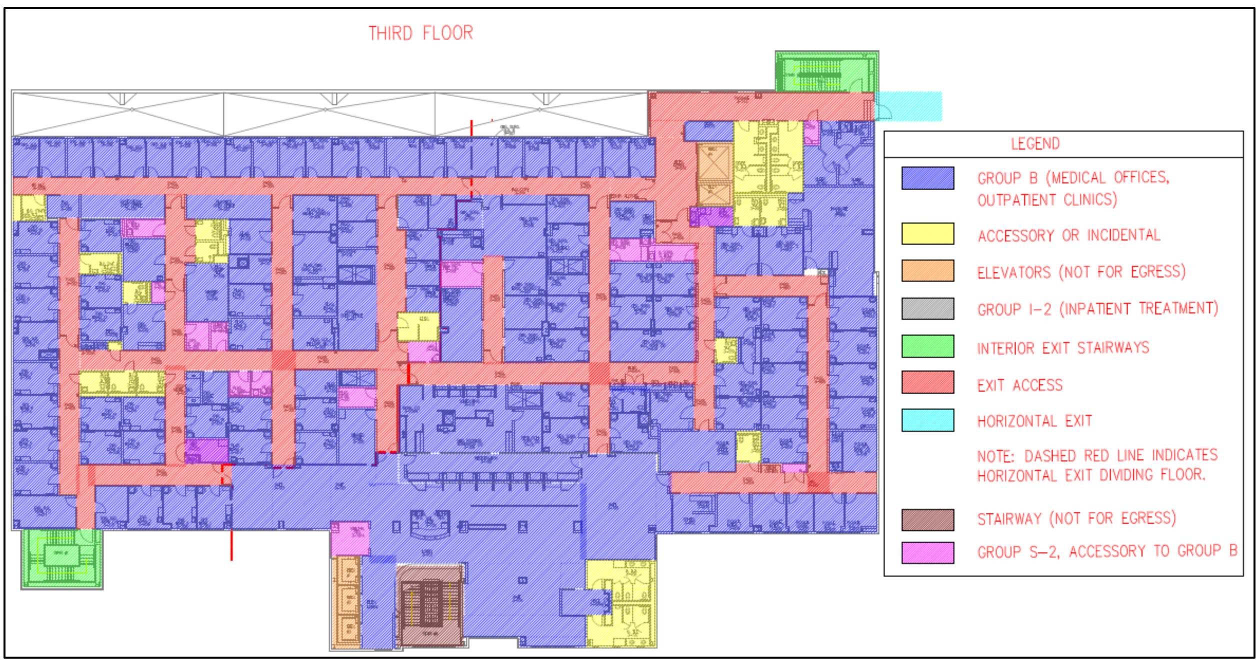

Figure 4. Third floor color-coded occupancy classifications

The mechanical penthouse containing the air handling units for the building's HVAC system is located above the 3rd floor of the building. The mechanical penthouse roof height does not exceed 18 feet above the 3rd floor roof deck, and the area does not exceed one-third of the available area of the roof deck. Therefore it satisfies the requirements of PBCC Section 1509.2 and will be considered as an additional portion of the 3rd floor of the building, and will not be included in determining the area of the building or number of stories as regulated by PBCC Section 503.1.

Because the Group I-2 Occupancy on the concourse level of the building is separated from the Group B Occupancy by a 2-hour rated fire barrier, the two occupancies are considered separated in accordance with PBCC Table 508.4. Therefore, this report will consider both the requirements for the Group I-2 Occupancy in the southwest corner of the concourse floor, and the requirements for the Group B Occupancy in the rest of the building.

The hospital adjoining the MCS Building has an occupied floor located 75 feet above the lowest level of fire department vehicle access, so it qualifies as a high-rise building. The MCS Building is separated from the adjoining hospital by a 2-hour rated fire barrier, so the MCS Building is not technically a separate building from the adjoining hospital (PBCC Section 706.1). However, for the purposes of the analysis presented in this report, the MCS Building will be analyzed as a stand-alone building.

Structural fire protection features are the main passive defense against the spread of fire in a building. The structural fire protection features of the MCS Building are discussed in the next section of this report.

4. Structural Fire Protection Requirements

The total height of the MCS Building, from the concourse floor to the penthouse roof, is 63 feet. The concourse height is 17 feet, and the penthouse is 14 feet 8 inches. That means that the highest occupied floor level above fire department access is 31 feet 4 inches. Because the highest occupied floor level is less than 75 feet above the lowest level of fire department vehicle access, the building is not considered to be a high-rise building (PBCC Section 202).

The building consists of 4 occupied stories. The area of the concourse level is 41,524 sq. ft., the first floor area is 40,887 sq. ft., the second floor area is 40,336 sq. ft., the third floor area is 37,624 sq. ft., and the penthouse area is 12,395 sq. ft. The penthouse is considered a portion of the 3rd floor, so the total 3rd floor area including the penthouse is 50,019 sq. ft. This gives a total gross floor area for the building of 172,776 sq. ft., with the largest floor area on the concourse level. Table 1 below summarizes this information.

Table 1. Summary of floor areas in the MCS Building

Floor Areas	
Concourse	41,524 sq. ft.
First	40,887 sq. ft.
Second	40,336 sq. ft.
Third	37,634 sq. ft.
Penthouse	12,395 sq. ft.

Using this height and area information, Section 503 of the 2012 PBCC can be consulted to determine possible construction types for the MCS Building. The Group I-2 and Group B parts of the building are not separated by a 2-hour horizontal assembly, and so are not separated in accordance with PBCC Section 510.2. The building has a non-separated, mixed-use occupancy of Groups I-2 and B, so the allowable building area/height is based on the most restrictive allowances for the considered occupancy groups (PBCC Section 508.3.2). This would be the Group I-2 Occupancy.

Table 2 illustrates allowable construction types based on Group I-2 Occupancy and the area/height of the building:

Table 2. Allowable construction types for the MCS Building

		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
Group	HEIGHT	UL	160	65	55	65	55	65	50	40
I-2	S	UL	4	2	1	1	NP	1	1	NP
	A	UL	UL	15,000	11,000	12,000	NP	12,000	9,500	NP

Even with sprinkler increases to allowable height/area and frontage increases to allowable area, no construction type other than Type I could be applied due to story limitations (and area limitations in several cases). Type I construction is the only type of construction that can be applied to a 4-story building with Group I-2 Occupancy. The MCS Building was designed to comply with the PBCC requirements for Type 1-A construction.

Structural fire protection requirements for building elements are found in Section 601 of the 2012 PBCC. These requirements for Type I-A construction are reproduced below in Table 3. The building elements for Type I-A construction are of noncombustible materials, except as permitted in PBCC Section 603 and elsewhere in the code (PBCC Section 602.2).

Table 3. Structural fire protection requirements for Type I-A Construction

Building Element	Type I-A
Primary structural frame	3 hours
Bearing walls	
Exterior	3 hours
Interior	3 hours
Nonbearing walls and partitions	
Interior	0 hours
Floor construction and associated secondary members	2 hours
Roof construction and associated secondary members	1 ½ hours

Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only. For the MCS Building, this applies to the mechanical penthouse floor, where the walls are only supporting the roof of the penthouse. The roof construction of the mechanical penthouse is less than 20 feet above the floor, so fire protection of the structural members is still required.

The nonbearing exterior walls and partitions cannot have a fire-resistance rating less than specified in PBCC Table 602 based on fire separation distance. For Group I-2 Occupancies and Type I-A construction, exterior nonbearing walls and partitions are required to be 1-hour rated, unless the fire separation distance is greater than 30 feet. This is true on the north, east, and south sides of the MCS Building, but not on the west side. The north, east, and south nonbearing walls and partitions do not have to be fire-resistance rated, but the west nonbearing walls must have a 1-hour rating.

PBCC Section 704.10 specifies that load-bearing structural members located within the exterior walls must have the highest fire-resistance rating between what is specified by PBCC Table 601 and by PBCC Table 602. According to PBCC Table 601, exterior bearing walls must have a 3-hour rating for Type I-A construction.

5. Building Construction and Structural Details

The MCS Building is a non-separated, mixed-use building that must be designed based on the requirements for a 4-story Group I-2 Occupancy. Therefore, it must either be designed as Type I-A or Type I-B construction. Based on the fire-resistance ratings information discussed below, the Mayo Clinic Specialties Building complies with the 2012 PBCC requirements for Type I-A construction.

5.1. Foundation

The MCS Building is constructed on a 4 inch concrete slab with Welded Wire Fabric (WWF) 6X6-W1.4xW1.4. This slab is laid on a 1 foot aggregate base material that acts as a vapor barrier to the bottom of the slab. Below the vapor barrier is 2 feet of recompacted engineered backfill. Spread footings are used for column locations. The slab is thickened and reinforced underneath the area used for the linear accelerators and the patient records room.

5.2. Primary Structure

The primary structure consists of wide flange columns (generally W14 shapes), wide flange steel girders (generally W21 and W24 shapes), and wide flange steel joists (generally W16 shapes). This applies everywhere except the linear accelerator portion of the concourse floor, which is entirely boxed in by concrete. Steel framing is used above this area starting on the 1st floor and continuing to the top of the building.

The columns are protected against fire using spray-applied fire resistive material (SFRM). Each column has a 3-hour rating using SFRM and is designed using UL x772. Where tube columns are used in the exterior walls, they are rated for 3-hours with SFRM using UL Design x771.

Roof and floor structural frame members are also protected against fire by using SFRM coating. Roof structural frame members are 3-hour rated, using UL Design S735, with an unrestrained beam classification. Floor structural frame members are 3-hour rated, using UL Design N708, with an unrestrained beam classification.

For Type I-A construction, Table 3 indicates that the primary structure must have a 3-hour fire-resistance rating. The primary structural members of the MCS Building are 3-hour rated, including the columns, the structural roof members, and the structural floor members. The MCS Building's primary structural frame is in compliance with the PBCC for Type I-A construction.

5.3. Floor and Roof Assemblies

The roof/floor assemblies used throughout the MCS Building are all 2-hour rated designs, using UL Design D916. SFRM is used to protect the secondary structural members in these assemblies, and the deck is rated based on the assembly of concrete and steel used. The roof/floor assembly is constructed using a 5 ¼" lightweight concrete slab, with WWF 6x6-W1.4xW1.4, and a 2" composite steel deck. This assembly is used throughout except above the linear accelerator vault and the roof of the mechanical penthouse.

The roof assembly of the mechanical penthouse is constructed of lightweight insulating concrete on a 1 5/16" steel form deck, and is 2-hour rated according to UL P922.

The linear accelerator vault roof is made of thick normal weight and heavy weight concrete, with a typically 55" slab.

Type I-A construction is required to have 2-hour rated floor construction and secondary members, and 1 ½ hour rated roof construction and secondary members. All roof and floor assemblies in the MCS Building are 2-hour rated, so they are in compliance with the PBCC requirements for Type I-A construction.

5.4. Exterior Walls

The exterior walls of the MCS Building are nonbearing. On the floors on the west side of the building, the exterior walls are constructed using 5/8″ Type X gypsum board on the interior face, 6″ steel studs 16″ on center with Batt insulation in the stud space, 5/8″ of Type X gypsum board sheathing on the exterior, covered with 1 ½″ of EIFS as the exterior finish. These walls are 1-hour rated.

On the north, east, and south sides of the building, the walls are constructed similarly to the walls described above, except with 3 5/8″ steel studs 24″ on center. These walls are non-rated. All walls on the penthouse level on constructed this way.

The MCS Building's exterior walls are in compliance with the PBCC requirements for Type I-A construction and Group I-2 Occupancy. The PBCC requires a 1-hour fire-resistance rating for nonbearing exterior walls with a fire separation distance less than 30 feet (west side of the building), and no rating is required for a fire separation distance greater than 30 feet (north, east, and south sides of the building).

5.5. Interior Nonbearing Walls and Partitions

The interior walls and partitions of the MCS Building are nonbearing. In locations not required to be separated with a rated wall, the walls are noncombustible and constructed using 5/8″ Type X gypsum board on both faces, and 3 5/8″ steel studs 24″ on center with Batt insulation in the stud space. These walls are non-rated.

The small storage spaces and large storage space on the east end of the building are separated from the rest of the Group B Occupancy area by a 1-hour rated wall. The Group I-2 Occupancy area is separated from the Group B Occupancy area by a 2-hour rated fire and smoke wall.

For Type I-A construction, the PBCC does not require interior nonbearing walls and partitions to be fire-resistance rated, unless they serve an occupancy separation function. The MCS Building is in compliance with this requirement.

6. Structural Fire Protection Summary

The primary structural frame, including the columns and the roof/floor structural members, are 3-hour rated. The exterior nonbearing walls are 1-hour rated on west-facing exposures and nonrated on other exposures. The interior nonbearing walls are 1 or 2-hour rated only for separation requirements, and are nonrated otherwise. The floor and roof assemblies are all 2-hour rated.

The MCS Building is a non-separated, mixed-use building that must be designed based on the requirements for a 4-story Group I-2 Occupancy. Therefore, it must either be classified as Type I-A or Type I-B construction. Based on the fire-resistance ratings information provided above, the Mayo Clinic Specialties Building complies with the 2012 PBCC requirements for Type I-A construction.

Passive structural features are one line of defense against a potential fire. Active features, including water-based suppression systems, are a second line of defense. The water-based suppression system in the MCS Building is discussed in the next section of this report.

7. Suppression System Requirements

The MCS Building includes a Group I fire area, and therefore is required to be equipped throughout with an automatic sprinkler system (PBCC Section 903.2.6). The sprinkler riser is required to be located in an interior exit stairway that is remotely located (PBCC Section 403.3.1.1).

The MCS Building is also required to be equipped with a standpipe system (PBCC Section 403.4.3). A Class I standpipe will be installed in the building since it will be equipped throughout with an automatic sprinkler system (PBCC Section 905.3.1). Connections to the Class I standpipe system will be provided in each stairway, and on each side of a wall adjacent to the exit opening of a horizontal exit, unless the area is reachable by an exit stairway hose connection with a 30-foot hose stream attached to 100 feet of hose (PBCC Section 905.4). Valves controlling water supply to the standpipe system will be supervised in the open position so that a change in the normal position of the valve will generate a supervisory signal at the supervising station (PBCC Section 905.9). Because the building will be equipped with a standpipe system, a fire hydrant will be located within 100 feet of the fire department connections (PFC Section 507.5.1.1). The standpipe system will be designed to provide 250 GPM at the two hydraulically most remote hose connections on the standpipe and at the topmost outlet of each of the other standpipes (NFPA 14 Section 7.10.1.2.1) at a minimum residual pressure of 100 psi (NFPA 14 Section 7.8.1).

The full design and hydraulic calculations for the wet standpipe system required in the MCS Building will not be completed as a part of this report. The contractor responsible for designing and installing the wet standpipe system will have their design and calculations approved by a registered design professional and the AHJ.

The sprinkler system in the building is required to be monitored by an approved supervising station (PBCC Section 901.6.1). Alarm, supervisory and trouble signals will be distinctly different and will be automatically transmitted to the approved supervising station (PBCC Section 903.4.1). An approved audible device, located on the exterior of the building in an approved location, will be connected to the automatic sprinkler system. This device will be activated by water flow equivalent to the flow of a single sprinkler of the smallest orifice size installed in the system (PBCC Section 903.4.2). Approved supervised indicating control valves will be provided at the point of connection to the riser on each floor (PBCC Section 903.4.3). The system will be tested and maintained in accordance with the PFC (PBCC Section 903.5).

Quick-response sprinklers will be used throughout all Light Hazard Occupancies in the MCS Building (PBCC Section 903.3.2).

Portable fire extinguishers will be installed throughout the building (PBCC Section 906.1). A portable fire extinguisher will be provided in every laboratory and in electrical and mechanical equipment rooms (PBCC Section 906.1). All portable fire extinguishers in the building will have at minimum a 2A:10B:C rating, and maximum travel distances between extinguishers will not exceed 75 feet (PBCC Table 906.3[1]). Portable fire extinguishers will be located in a conspicuous location, unobstructed and unobscured from view (PBCC Section 906.5).

8. Occupancy Hazard Classification and Design Criteria

The MCS Building mainly consists of offices and outpatient clinics. All of these spaces are expected to experience fires of relatively low heat release rate, and are classified as Light Hazard occupancies under NFPA 13 Section 5.2.

However, the MCS Building also contains rooms with high-powered electrical equipment, mechanical rooms, and lab storage spaces. The electrical and mechanical equipment spaces are expected to experience fires with moderate rates of heat release, and are classified as Ordinary Hazard Group 1 under NFPA 13 Section 5.3.1.1.

The storage spaces in the MCS Building are mainly used to store paper products, office supplies, and medical instruments and equipment, not exceeding 8 feet in height. Because quantity of combustibles in these spaces is moderate, combustibility is low, and stockpiles of combustibles do not exceed 8 feet in height, the storage spaces are classified as Ordinary Hazard Group 1 under NFPA 13 Section 5.3.1.1.

Color-coded floor plans indicating the NFPA 13 Occupancy Classification of each space in the building are shown below in Figure 5, Figure 6, Figure 7, and Figure 8. These plans are reproduced in larger print in Appendix C; they are shown below for convenience.

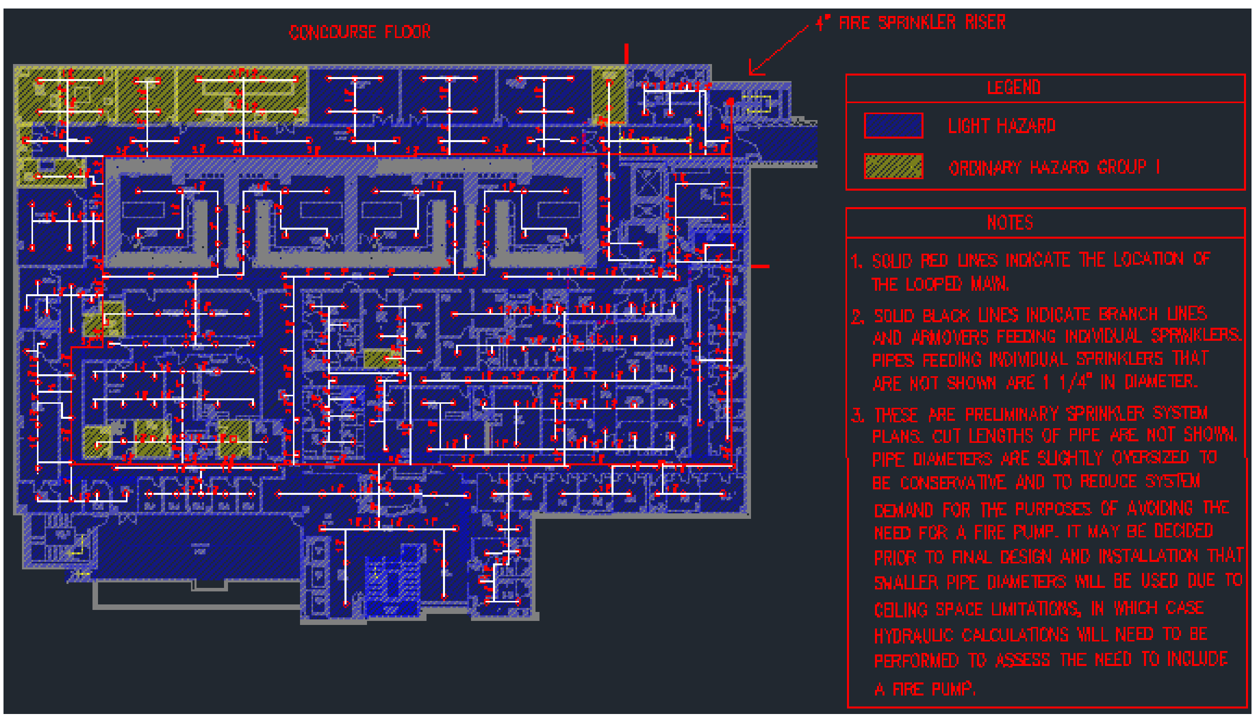

Figure 5. NFPA 13 Occupancy Hazard classifications for the concourse floor

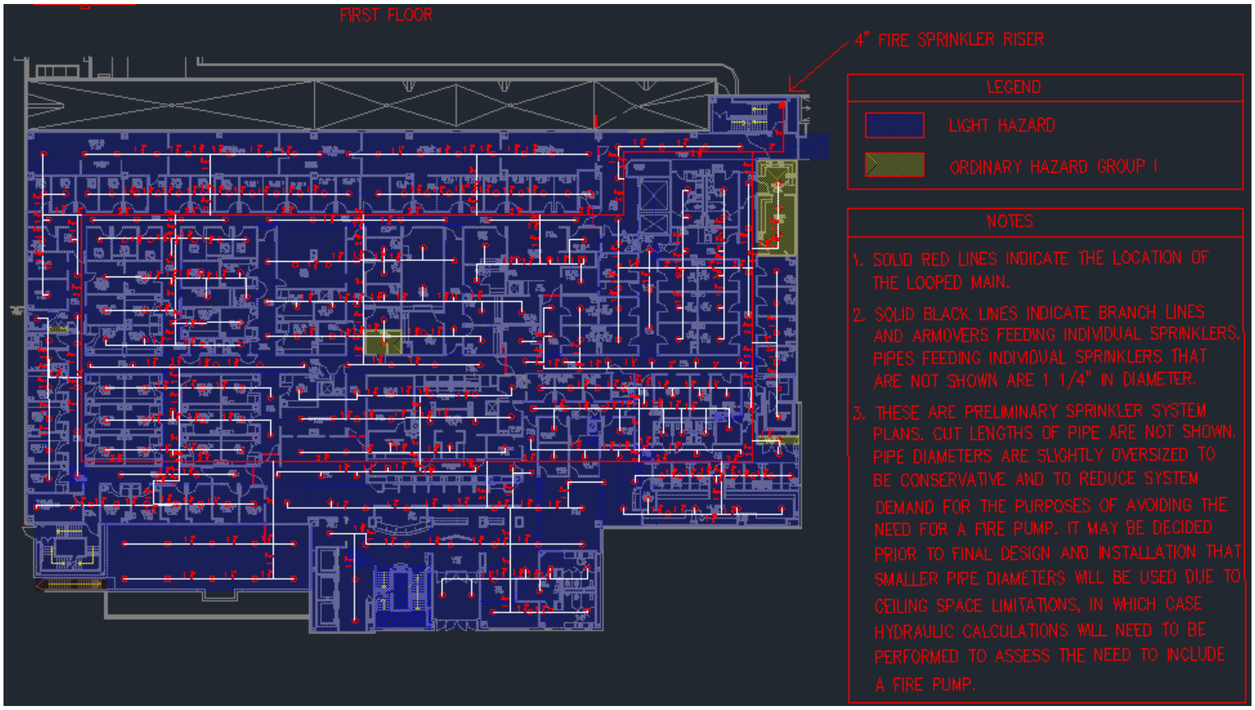

Figure 6. NFPA 13 Occupancy Hazard classifications for the first floor

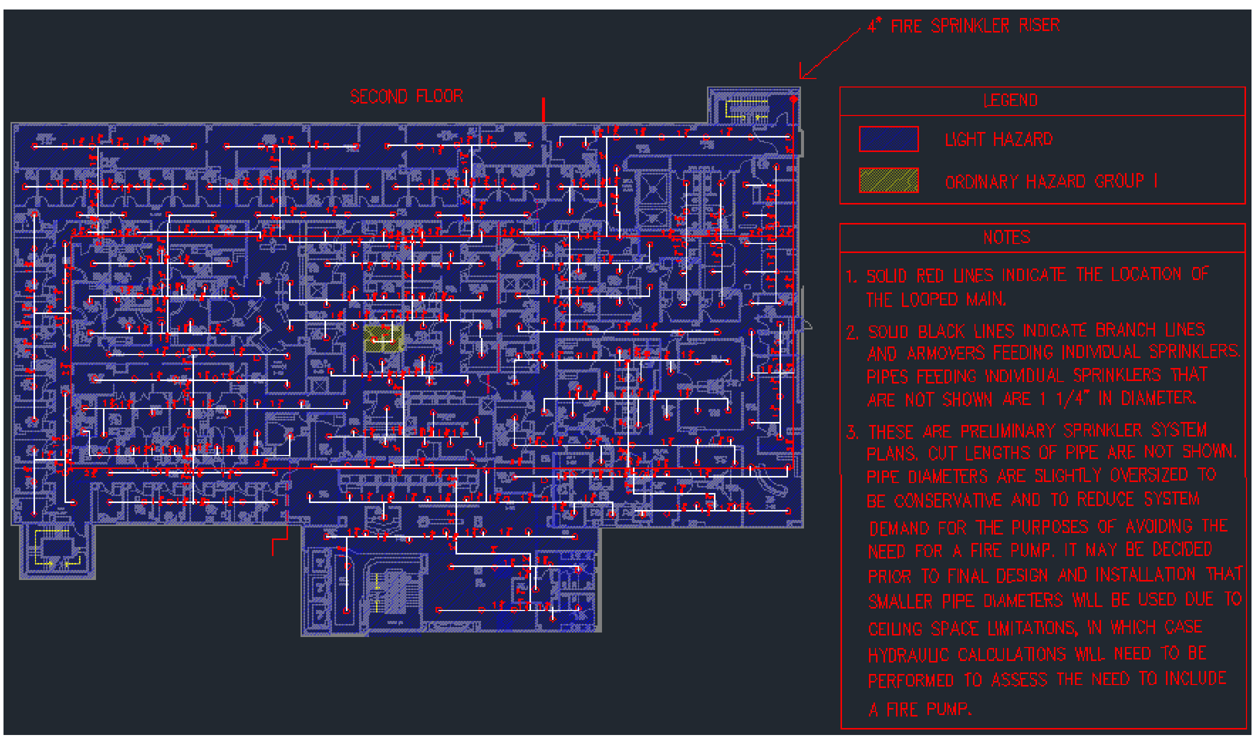

Figure 7. NFPA 13 Occupancy Hazard classifications for the second floor

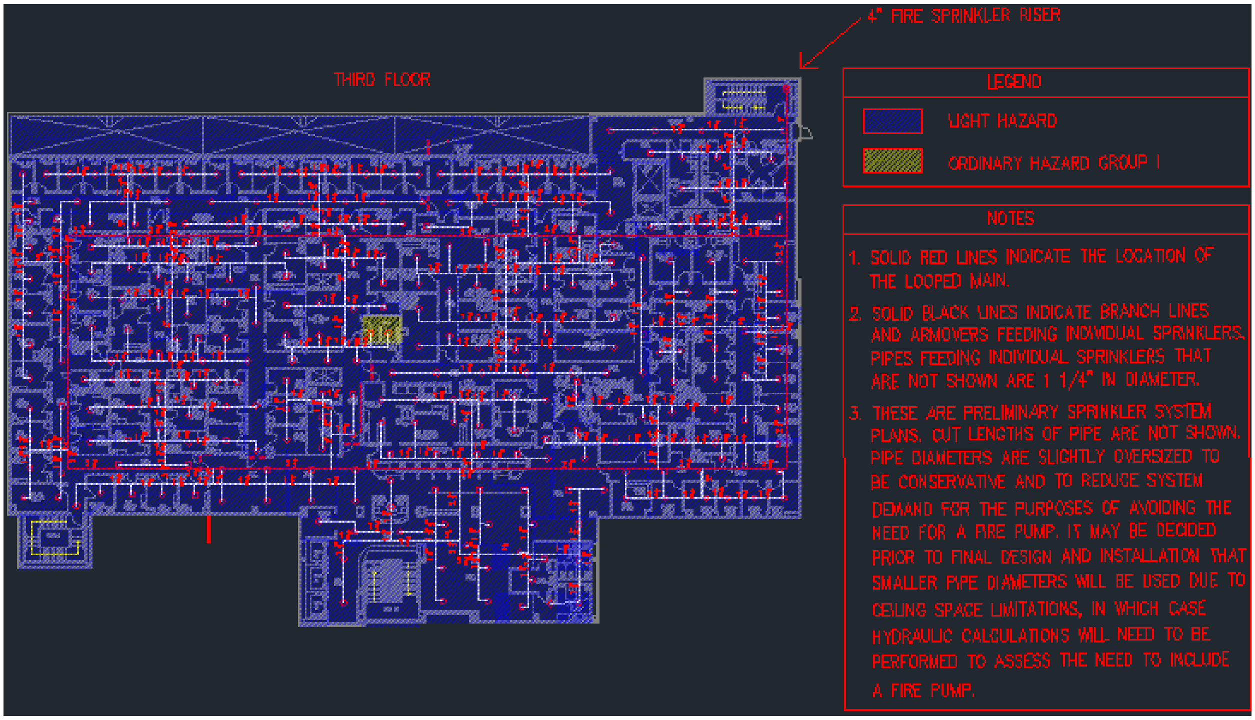

Figure 8. NFPA 13 Occupancy Hazard classifications for the third floor

The density/area design method will be used to design the fire suppression systems for the building (NFPA 13 Section 11.2.3.2).

Areas classified as Light Hazard will be protected with a wet pipe sprinkler system, with ½ inch sprinkler orifice and nominal K-factor of 5.6 minimum (NFPA 13 Section 8.3.4.1), with a maximum sprinkler coverage area of 225 square feet (NFPA 13 Table 8.6.2.2.1[a]). The sprinklers will be designed to provide a minimum density of 0.1 GPM/ft^2 for the hydraulically most remote 1,500 square feet (NFPA 13 Figure 11.2.3.1.1). A hose stream demand of 100 GPM will be provided (NFPA 13 Table 11.2.3.1.2). The water supply must last for a duration of 30 minutes (NFPA 13 Table 11.2.3.1.2). A reduction of the hydraulically most remote area is permitted with the use of quick-response sprinklers (NFPA 13 Section 11.2.3.2.3).

Areas classified as Ordinary Hazard Group 1 will be protected with a wet pipe sprinkler system, with ½ inch sprinkler orifice and nominal K-factor of 5.6 minimum, with a maximum sprinkler coverage area of 130 square feet (NFPA 13 Table 8.6.2.2.1[b]). The sprinklers will be designed to provide a minimum density of 0.15 GPM/ft^2 for the hydraulically most remote 1,500 square feet (NFPA 13 Figure 11.2.3.1.1). A hose stream demand of 250 GPM will be provided (NFPA 13 Table 11.2.3.1.2). The water supply must last for a duration of 60 minutes (NFPA 13 Table 11.2.3.1.2), since all sprinkler system waterflow alarm devices and supervisory devices are electrically supervised and monitored at an approved location (NFPA 13 Section 11.2.3.1.3).

Because a wet pipe system is used, all areas in the building are Light Hazard or Ordinary Hazard Group 1, ceiling height never exceeds 10 feet, and there are no unprotected ceiling pockets, the design area is permitted to be reduced (NFPA 13 Section 11.2.3.2.3.1). For a ceiling height of 10 feet, the design area is permitted to be reduced by 40 percent. Therefore, all Light Hazard lobby areas will be designed to a density of 0.1 GPM/ft^2 for the hydraulically most remote 900 square feet, and all Ordinary Hazard Group 1 lobby areas will be designed to a density of 0.15 GPM/ft^2 for the hydraulically most remote 900 square feet.

Quick-response ordinary temperature sprinklers, which will be the concealed pendent type, will be installed in all areas, except where listed for a particular application as follows:

- Standard response, 200°F sprinklers are required to be installed in elevator machine rooms. Sidewall type and upright type sprinklers may be used where required in these areas.

- Quick-response, 200°F sprinklers are required to be installed in electrical/mechanical rooms. Sidewall type and upright type sprinklers may be used where required in these areas.

Sprinkler positioning and locating will follow the requirements outlined in NFPA 13 Section 8.5.

9. Water Supply

The water supply for the MCS Building was determined via a flow test. The measured static pressure was 75 psi, and the residual pressure was 70 psi with 2,430 GPM flowing. Details of the flow test performed are shown below in Table 4.

Table 4. Details of hydraulic flow test performed for MCS Building

FLOW TEST INFO	
DATE	6/19/15
TIME	1:00 PM
STATIC P.S.I.	75
RESIDUAL P.S.I.	70
COEFFICIENT	.9
ORFICE SIZE	4"
FLOW	2430
LOCATION	5777 E. MAYO BLVD
BY WHOM	CITY OF PHOENIX

The MCS Building is provided access to a 12 inch fire line loop with two (2) separate connections to a 24 inch city water line. Multiple fire hydrants are located around the MCS Building and adjoining hospital to comply with PBCC and PFC requirements. A water supply tank is not required for the building and is not provided.

10. System Hardware and Installation Requirements

Where they are required, sprinklers will be installed throughout in accordance with NFPA 13 (PBCC Section 903.3.1.1).

Only new sprinklers will be installed (NFPA 13 Section 6.2.1). A supply of at least six (6) spare sprinklers will be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced (NFPA 13 Section 6.2.9.1). A minimum of two (2) sprinklers of each type and temperature rating should be provided (NFPA 13 Section A.6.2.9.1).

Underground pipe will not be permitted to extend into the building through the slab or wall not more than 24 inches (NFPA 13 Section 6.3.1.1.1). Schedule 40 black steel pipe will be used in aboveground portions of the system, and C150 Class 900 PVC plastic pipe will be used in underground portions of the system. Piping will meet the requirements of NFPA 13 Chapter 6.

All valves controlling connections to water supplies and to supply pipes to sprinklers will be listed indicating valves (NFPA 13 Section 6.7.1.3). A listed underground gate valve equipped with a listed indicator post will be permitted (NFPA 13 Section 6.7.1.3.1). Drain and test valves will be approved (NFPA 13 Section 6.7.3). Valves will be identified in accordance with NFPA 13 Section 6.7.4. The floor control valves and valves controlling flow to sprinklers in circulating closed loop systems will be supervised by a central station (NFPA 13 Section 8.16.1.1.2.2).

The fire department connections to the system will consist of two (2) 2 ½ inch connections using NH internal threaded swivel fittings (NFPA 13 Section 6.8.1), and will be of an approved type (NFPA 13 Section 6.8.3). The pipe size for the fire department connections will be a minimum of 4 inches (NFPA 13 Section 8.17.2.3).

The alarm apparatus for the wet pipe system used for the building will consist of a listed alarm check valve or other listed waterflow detection alarm device with the necessary attachments required to give an alarm (NFPA 13 Section 6.9.2.1). An alarm unit will include a listed mechanical alarm, horn, or siren or a listed electric gong, bell, speaker, horn, or siren (NFPA 13 Section 6.9.3.1).

Signs will be attached to various components of the sprinkler system in accordance with NFPA 13 Table A.6.10.

An approved pressure gauge will be installed in the system riser (NFPA 13 Section 7.1.1.1). Pressure gauges will also be installed above and below each alarm check valve or system riser check valve where such devices are present (NFPA 13 Section 7.1.1.2).

The wet pipe system will be provided with a listed relief valve not less than ½ inch in size and set to operate at 175 psi or 10 psi in excess of the maximum system pressure, whichever is greater (NFPA 13 Section 7.1.2.1).

Provisions will be made to drain the system in accordance with NFPA 13 Section 8.16.2.4, and to flush the system in accordance with NFPA 13 Section 8.16.3.

The alarm test connection for the system will be in accordance with NFPA 13 Section 8.17.4.2.

Sprinkler system piping will be hung, seismically braced, and restrained in accordance with Chapter 9 of NFPA 13.

11. Sprinkler System Design Layout

The water supply for the MCS Building automatic sprinkler system originates at the point of connection where the water supply information displayed in Table 4 was measured. This point of connection is to the 12 inch fire loop that encompasses the Mayo Clinic Campus. There is a 6 inch pipe that tees off of this point of connection, and leads to the MCS Building sprinkler system.

Once this 6 inch pipe reaches the MCS Building, it penetrates the building at the first floor level. It is attached to the main building riser, located in the southeast stairway. The main building riser has a nominal diameter of 4 inches. It continues below the first floor into the concourse level, and above the first floor up to the third floor.

The general layout of the sprinkler system on the third floor is shown below in Figure 9. Only the third floor is displayed because the general layout is very similar to the other floors.

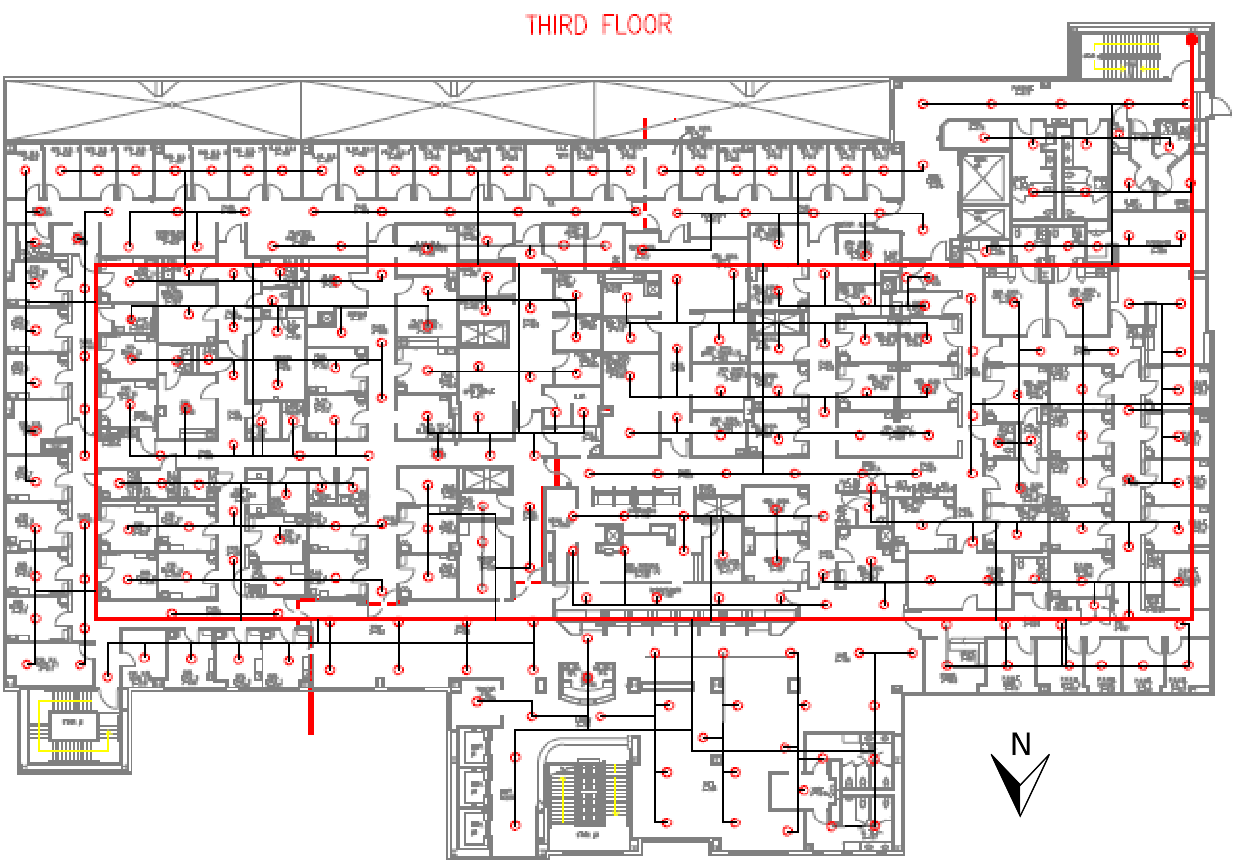

Figure 9. General fire sprinkler system layout

Every floor in the MCS Building is served by a 3 inch looped supply main that circles its way around the floor. There are multiple tree "sub-systems" that project off of this 3 inch looped supply main. Some of these sub-systems are served by 2 ½ inch cross mains that project off the looped main, while others are served by 2 inch cross mains that project off the looped main.

Generally, each cross main serves several branch lines ranging in nominal diameters from 2 inch to 1 ½ inch pipes. Attached to these branch lines are 1 ¼ inch arm-overs that feed each sprinkler in the building. The size chosen for these arm-overs was 1 ¼ inch instead of 1 inch in case the owner of the building ever needs to alter temporary partition locations or re-purpose the space, in which case the arm-overs can be extended to accommodate additional 1 inch pipes. This provides a flexibility of the system to be altered in future tenant improvements, without needing to upgrade the sizes of the main or branch line piping, which would be much more expensive.

12. Hydraulic Calculations

Hydraulic calculations for each remote area analyzed in the MCS Building were performed using the Hass sprinkler system calculation program. The Hass sprinkler system calculation program satisfies the requirements needed for calculation worksheets outlined in NFPA 13 Section 23.3.5.6.

The hydraulically most demanding area is located on the third floor since it is the highest above the point where the water supply enters the building. Since roughly 0.44 psi is lost for every foot in gained elevation, the third floor will suffer a loss of about 19 psi due to elevation (the main pipe supplying third floor is 44 feet above the point where the water supply enters the building). This is compared to a loss of 12.1 psi for the main supplying the second floor, 5.2 psi for the main supplying the first floor, and a *gain* of 2.2 psi for the main supplying the concourse floor. The inherent 19 psi handicap experienced by the third floor just due to the elevation loss makes the third floor more hydraulically demanding than the other floors.

Because the sprinkler system utilizes a looped main design, it is not obvious through visual inspection which area of the system on the third floor is the hydraulically most demanding. For this reason, multiple possible design areas were selected, using the density/area method. The various areas selected were all candidates for the hydraulically most remote 900 square feet, since the conditions for this design area reduction were all fulfilled.

A complete Hass model of the entire third floor sprinkler system was constructed so that it would be possible to test the various design areas selected to determine which area was actually the hydraulically most demanding.

The Hass calculations performed for each individual design area selected are attached to this report in Appendix D. The calculations for each design area are numbered, and they correspond to the accompanying design area shown in Figure 10 and in Appendix E. Sprinklers in each Light Hazard area must discharge a minimum of 22.5 GPM (the maximum Light Hazard sprinkler coverage of 225 sq. ft. multiplied by the design density of 0.1 GPM/ft^2). Sprinklers in each Ordinary Hazard Group 1 area must discharge a minimum of 19.5 GPM (the maximum Ordinary Hazard sprinkler coverage of 130 sq. ft. multiplied by the design density of 0.15 GPM/ft^2). A hose demand of 250 GPM at the base of riser (BOR) is required to be included in the hydraulic calculations for all areas, in accordance with NFPA 13 Section 11.1.6.1, Condition 1.

As shown by the attached hydraulic calculations, the most hydraulically demanding area of the candidates selected was Area 1, which encompasses 8 sprinklers on the eastern end of the third floor. This design area is at least 900 square feet. This design area must be supplied with 22.5 GPM/ft^2 minimum because the worst-case sprinkler is in a Light Hazard area with 225 sq. ft. of coverage. This design area also must be supplied with a minimum 250 GPM hose allowance at the base of the riser (NFPA 13 Section 11.1.6.1, condition 1). The system demand for this design area is 446 GPM at a pressure of 69.2 psi, with an available supply of 446 GPM at a pressure of 74.8 psi.

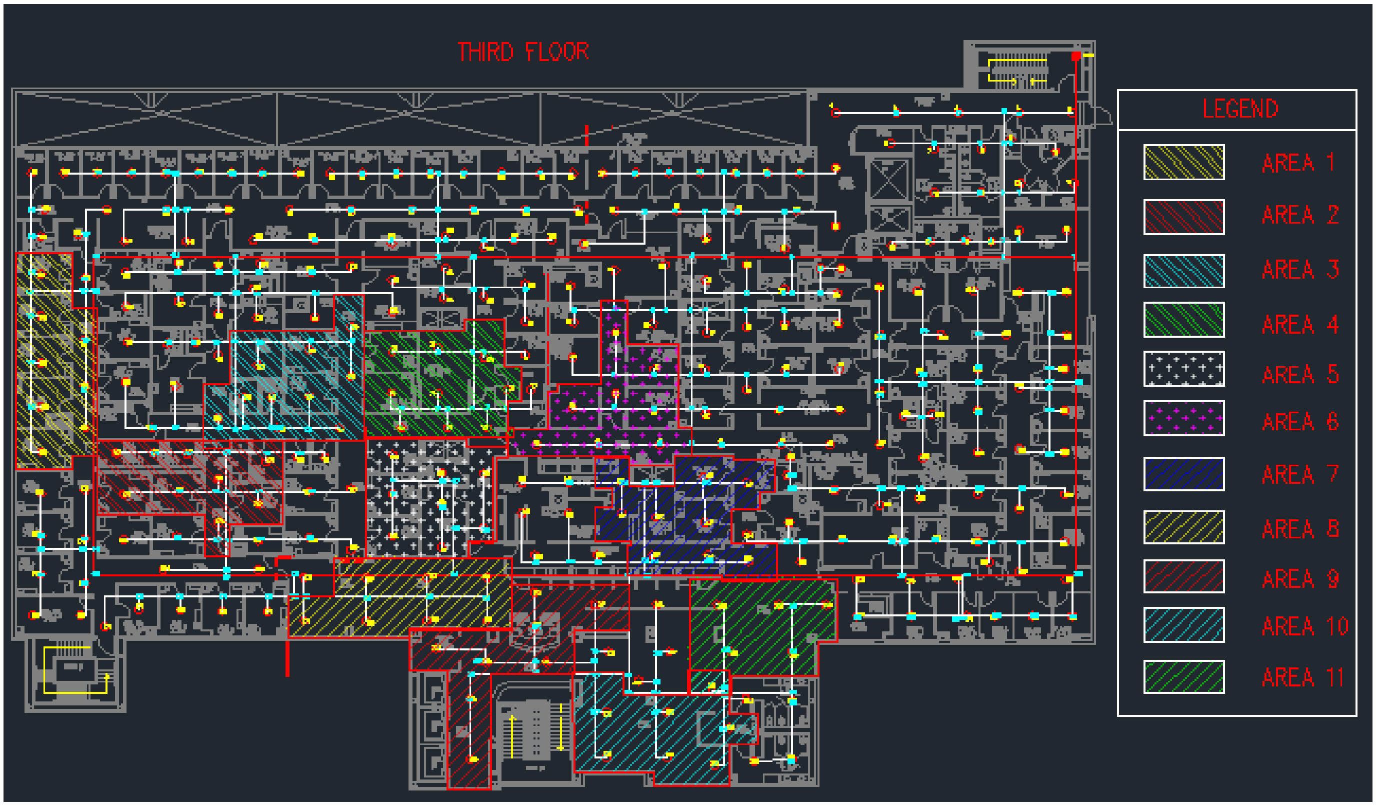

Figure 10. Design areas chosen for calculation on the third floor

Hand calculations were used to confirm that the Hass sprinkler system program calculated this demand accurately. The hand calculations are attached to this report in Appendix F. The calculated system demand is 446 GPM at a pressure of 69.1 psi. This calculated flow matches well with the flow calculated by Hass, and the two pressures also match reasonably well, with only a 0.1 psi difference. This difference is due to Hass utilizing normal pressure to calculate orifice flow, while total pressure was used to calculate orifice flow in the hand calculations. Total pressure was used to calculate orifice flow in the hand calculations in accordance with NFPA 13 Section 23.4.4.9.1. Although normal pressure is permitted to be used by NFPA 13 Section 23.4.4.9.2, it is more conservative to use total pressure to calculate orifice flow.

A summary of the system demand for each area considered in shown below in Table 5.

Table 5. System demand summary for each candidate design area examined

Area	Required Pressure	Available Pressure	Margin Between Required and Available Pressure	Required Flow (with hose allowance of 250 GPM at BOR)
1	69.2 psi	74.8 psi	5.6 psi	446 GPM
2	65.0 psi	74.8 psi	9.8 psi	473 GPM
3	66.5 psi	74.8 psi	8.3 psi	486 GPM
4	64.9 psi	74.8 psi	9.9 psi	474 GPM
5	63.8 psi	74.8 psi	11.0 psi	442 GPM
6	58.5 psi	74.8 psi	16.3 psi	442 GPM
7	64.2 psi	74.8 psi	10.6 psi	471 GPM
8	66.0 psi	74.8 psi	8.8 psi	423 GPM
9	68.6 psi	74.8 psi	6.2 psi	447 GPM
10	51.9 psi	74.8 psi	22.9 psi	413 GPM
11	56.1 psi	74.8 psi	18.7 psi	391 GPM

13. Suppression System Inspection, Testing, and Maintenance Requirements

The inspection, testing, and maintenance (ITM) requirements for the MCS Building sprinkler system are described below. The sprinkler system will be inspected, tested, and maintained in accordance with NFPA 25 (PFC Section 901.6.1).

The property owner or designated representative will be responsible for properly maintaining the sprinkler system in the MCS Building (NFPA 25 Section 4.1.1). ITM will be performed by qualified personnel (NFPA 25 Section 4.1.1.2). Where the property owner or designated representative is not the occupant, the property owner or designated representative will be permitted to delegate the authority for ITM and the managing of impairments of the fire protection system to a designated representative (NFPA 25 Section 4.1.1.3). Where a designated representative has received the authority for ITM and the managing of impairments, the designated representative will comply with the requirements identified for the property owner or designated representative throughout NFPA 25 (NFPA 25 Section 4.1.1.4).

Where changes in the occupancy, hazard, water supply, building modification, or other condition that affects the installation criteria of the sprinkler system are identified, corrective action will be taken to evaluate the adequacy of the installed system to continue to protect the building (NFPA 25 Section 4.1.7.1).

A summary of the components of the sprinkler system in the MCS Building and their ITM frequencies in accordance with NFPA 25 are summarized in Table 6 below.

Table 6. MCS Building sprinkler system ITM frequency requirements

Component	Inspection	Testing	Maintenance
Water pressure gauges	Quarterly (NFPA25 Table 5.1.1.2)	5 years (NFPA 25 Table 5.1.1.2)	Replace if found deficient
Waterflow alarm devices	Quarterly (NFPA 25 Table 5.1.1.2)	Mechanical devices – Quarterly Vane and pressure switch type devices – Semiannually (NFPA 25 Table 5.1.1.2)	Replace if found deficient
Fire department connections	Quarterly (NFPA 25 Table 13.1.1.2)	5 years (NFPA 25 Section 13.7.4)	Repair or replace as necessary (NFPA 25 Section 13.7.2)
Sprinklers	Annually Spare sprinklers – Annually (NFPA 25 Table 5.1.1.2)	Quick-response – 20 years and every 10 years thereafter (NFPA 25 Table 5.1.1.2)	If found deficient, replace with new sprinkler appropriate for system (NFPA 25 Section 5.4.1.3)
Control valves	Sealed – Weekly Locked, electrically supervised – Monthly (NFPA 25 Table 13.1.1.2)	Position – Annually Operation – Annually Supervisory – Semiannually (NFPA 25 Table 13.1.1.2)	Annually (NFPA 25 Table 13.1.1.2)
Valve supervisory signal devices	Quarterly (NFPA 25 Table 13.1.1.2)	Semiannually (NFPA 25 Table 13.1.1.2)	Replace or repair as needed
Hanger/seismic bracing	Annually (NFPA 25 Table 5.1.1.2)	Not required	Replace or repair as needed
Pipe and fittings	Annually Obstruction, internal inspection of piping – 5 years (NFPA 25 Table 5.1.1.2)	Not required independently	Replace or repair as needed
Main drain	Visual inspection periodically to confirm no physical damage.	Annually/Quarterly (NFPA 25 Table 13.1.1.2)	Replace or repair as needed
Backflow preventer	Reduced pressure – Weekly/monthly (NFPA 25 Table 13.1.1.2)	Annually (NFPA 25 Table 13.1.1.2)	Replace or repair as needed.

Sprinklers will not show signs of leakage, corrosion, foreign materials, paint, or physical damage, and will be installed in the correct orientation (NFPA 25 Section 5.2.1.1.1). Any sprinkler that shows signs of leakage, corrosion, physical damage, loss of glass bulb fluid, loading, or painting (other than sprinkler manufacturer) will be replaced (NFPA 25 Section 5.2.1.1.2). The correct supply of spare sprinklers will be maintained, and inspected annually (NFPA 25 Section 5.2.1.4). Sprinklers manufactured using quick-response elements that have been in service for 20 years will be replaced (NFPA 25 Section 5.3.1.1.1.3). Replacement sprinklers will have the proper characteristics for the application intended (NFPA 25 Section 5.4.1.2). Only new, listed sprinklers will be used to replace existing sprinklers (NFPA 25 Section 5.4.1.3). A supply of at least six spare sprinklers will be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced (NFPA 25 Section 5.4.1.5).

Pipe and fittings will be in good condition and free of mechanical damage, leakage, and corrosion (NFPA 25 Section 5.2.2.1). Sprinkler piping will not be subjected to external loads by materials resting on or hung from the pipe (NFPA 25 Section 5.2.2.2).

Hangers and seismic braces will not be damaged, loose, or unattached (NFPA 25 Section 5.2.3.1).

Gauges on wet pipe systems will be inspected quarterly to ensure that they are in good condition and that normal water supply pressure is being maintained (NFPA 25 Section 5.2.4.1). Gauges will be replaced every 5 years or tested every 5 years with a calibrated gauge (NFPA 25 Section 5.3.2.1).

Waterflow alarm and supervisory signal initiating devices will be inspected quarterly to verify that they are free of physical damage (NFPA 25 Section 5.2.5). Vane-type and pressure switch-type waterflow alarm devices will be tested semiannually (NFPA 25 Section 5.3.3.2). Testing waterflow alarm devices on wet pipe systems will be accomplished by opening the inspector’s test connection (NFPA 25 Section 5.3.3.3).

Valves secured with locks or supervised in accordance with applicable NFPA standards will be inspected monthly (NFPA 25 Section 13.3.2.1.1). Control valve supervisory alarm devices will be inspected quarterly to verify that they are free of physical damage (NFPA 25 Section 13.3.2.1.2). After any alterations or repairs to the sprinkler system, an inspection will be made to ensure that the system is in service and all valves are in the normal position and properly sealed, locked, or electrically supervised (NFPA 25 Section 13.3.2.1.3). Valve inspections will verify that the valves are in the normal open or closed position, sealed, locked, or supervised, accessible, free from external leaks, and provided with applicable identification (NFPA 25 Section 13.3.2.2). Each control valve will be operated annually through its full range and returned to its normal position (NFPA 25 Section 13.3.3.1). A main drain test will be conducted every time the control valve is closed and reopened at the system riser (NFPA 25 Section 13.3.3.4). Valve supervisory switches will be tested semiannually (NFPA 25 Section 13.3.3.5.1). Alarm valves and system riser check valves will be externally inspected monthly and will verify that the gauges indicate normal water pressure is being maintained, the valve is free of physical damage, all valves are in the appropriate open or closed position, and the retarding chamber or alarm drains are not leaking (NFPA 25 Section 13.4.1.1). Alarm valves and their associated strainers, filters, and restriction orifices will be inspected internally every 5 years (NFPA 25 Section 13.4.1.2).

The valves on backflow prevention assemblies, secured with locks or electrically supervised, will be inspected monthly (NFPA 25 Section 13.6.1.1.1). Backflow prevention assemblies will be inspected internally every 5 years to verify that all components operate correctly, move freely, and are in good condition (NFPA 25 Section 13.6.1.4). Backflow preventers will be exercised annually by conducting a forward flow test at a minimum flow rate of the system demand (NFPA 25 Section 13.6.2.1). Maintenance of all backflow prevention assemblies will be conducted by a qualified individual following the manufacturer’s instructions in accordance with the procedure and policies of the AHJ (NFPA 25 Section 13.6.3).

Fire department connections will be inspected quarterly to verify that they are visible and accessible, couplings are not damaged and rotate smoothly, plugs and caps are in place and undamaged, gaskets are in place and in good condition, identification signs are in place, the check valve is not leaking, the automatic drain valve is in place and operating properly, the clapper is in place and operating properly, and the interior of the connection is not obstructed (NFPA 25 Section 13.7.1). The piping from the fire department connection to the fire department check valve will be hydrostatically tested at 150 psi for 2 hours at least once every 5 years (NFPA 25 Section 13.7.4).

The general information signs required by NFPA 13 to be attached to the riser will be inspected annually to verify that it is provided, securely attached, and legible (NFPA 25 Section 5.2.9).

The standpipe system installed in the building will be inspected, tested, and maintained in accordance with NFPA 25 Chapter 6. NFPA 25 Table 6.1.1.2 provides a summary of standpipe system ITM requirements.

Impairment conditions of the water-based suppression systems in the MCS Building will follow the requirements of NFPA 25 Chapter 15. NFPA 25 Section A.3.3.7 and Table A.3.3.7 provide examples for classifying conditions needing repair or correction that are identified during the ITM process. NFPA 25 Table A.3.3.7 is not all-inclusive but intends to provide guidance in responding to the conditions described.

14. Suppression System Summary

The MCS Building is equipped throughout with a sprinkler system. The as-built drawings for the sprinkler system installed in the actual building could not be obtained, so the sprinkler system described in this report was designed from the ground up. The sprinkler system was designed in accordance with the applicable requirements of NFPA 13, and care should be taken in both the installation and future ITM of the system to ensure it remains in good working condition throughout the life of the building.

If installed and maintained properly, the suppression system will provide an important active means of fire protection for the MCS Building. The sprinklers also serve as a detection system, since each sprinkler is essentially a heat detector. But this important means of fire detection on its own is not sufficient to provide early warning and notification to occupants everywhere in the building. The MCS Building is also fully equipped with a fire alarm and detection system that serves this purpose, which is discussed in the next section of this report.

15. Fire Alarm System Requirements

An approved automatic fire alarm system has been installed throughout the MCS Building, in accordance with PBCC Section 907.2. The automatic fire alarm system must be monitored by a supervising station (PFC 907.6.5), and the installed fire alarm system is monitored by a central station located on the Mayo Clinic Campus in accordance with this requirement.

Wiring for the MCS Building fire alarm system must comply with the requirements of NPFA 70 and NFPA 72 (PBCC Section 907.6.1). Initiating devices used in the system follow the requirements of NFPA 72 Chapter 17, and notification appliances used in the system follow the requirements of NFPA 72 Chapter 18. There is an emergency voice/alarm communication system provided in the MCS Building, which is installed in accordance with NFPA 72 requirements.

16. Fire Alarm System Design Layout

The MCS Building fire alarm system is a zoned system, where the activation of initiating devices results in the activation of notification appliances in the affected zones. The specific zoning scheme is discussed below, along with the requirements for trouble, supervisory, and alarm signal disposition.

16.1. Fire Alarm System Zoning Scheme

Each floor of a building must be zoned separately, and a zone will not exceed 22,500 square feet. The length of any zone will not exceed 300 feet in any direction (PBCC Section 907.6.3). A zoning indicator panel and the associated controls will be provided in an approved location. The visual zone indication will lock in until the system is reset and will not be canceled by the operation of an audible-alarm silencing switch (PBCC Section 907.6.3.1).

Each side of the floor-dividing horizontal exit on every floor is a separate fire alarm zone, all of which are less than 22,500 square feet in total area and less than 300 feet long in any direction. The MCS Building therefore has eight (8) separate fire alarm zones. Upon activation of an initiating device in a zone, the audible and visible notification appliances will activate in both zones on the floor, resulting in a voice message calling for evacuation of the affected floor. The floors above and below hear a pre-recorded message informing occupants to standby for evacuation. The evacuation procedure is discussed in greater detail later in this report.

16.2. Fire Alarm System Sequence of Operations and Signal Disposition

The sequence of operations (SOO) for the MCS Building fire alarm system is reproduced below in Table 7, and in larger print in Appendix G.

Table 7. Fire alarm sequence of operations matrix

FIRE ALARM MATRIX	ANNUNCIATE ON FIRE ALARM PANEL AS ALARM	ANNUNCIATE ON FIRE ALARM PANEL AS TROUBLE	ANNUNCIATE ON FIRE ALARM PANEL AS SUPERVISORY	ACTIVATE SPEAKERS/STROBE & STROBE IN ASSOCIATED ZONES	ACTIVATE PRIMARY ELEVATOR RECALL	ACTIVATE AUXILIARY ELEVATOR RECALL	SEND SIGNAL TO ELEVATOR SHUNT TRIP PANEL	SEND SIGNAL TO RED HAT ELEVATOR CAB LIGHT	ACTIVATE DOOR HOLDER RELEASE ON FLOOR OF INCIDENCE	CLOSE ASSOCIATED FIRE/SMOKE DAMPER ZONE	ANNUNCIATE ON FIRE ALARM ANNUNCIATION PANEL AS ALARM	ANNUNCIATE ON FIRE ALARM ANNUNCIATION PANEL AS TROUBLE	ANNUNCIATE ON FIRE ALARM ANNUNCIATION PANEL AS SUPERVISORY	SHUTDOWN ASSOCIATED AHU UNIT & EXHAUST FAN	SEND ALARM SIGNAL TO CENTRAL STATION AS ALARM	SEND WATERFLOW SIGNAL TO CENTRAL STATION AS ALARM	SEND SUPERVISORY SIGNAL TO CENTRAL STATION AS SUPERVISORY	SEND TROUBLE SIGNAL TO CENTRAL STATION AS TROUBLE
SINGLE ZONE AREA SMOKE DETECTOR ACTIVATION	X			X					X	X	X				X			
SINGLE ZONE AREA THERMAL DETECTOR ACTIVATION	X			X					X	X	X				X			
SINGLE ZONE MANUAL PULL STATION ACTIVATION	X			X					X	X	X				X			
SINGLE ZONE ACTIVATION OF SPRINKLER SYSTEM WATERFLOW SWITCH	X			X					X	X	X				X	X		
TWO ZONE AREA SMOKE DETECTOR ACTIVATION	X			X					X	X	X			X	X			
TWO ZONE AREA THERMAL DETCTOR ACTIVATION	X			X					X	X	X			X	X			
TWO ZONE MANUAL PULL STATION ACTIVATION	X			X					X	X	X			X	X	X		
TWO ZONE ACTIVATION OF SPRINKLER SYSTEM WATERFLOW SWITCH	X			X					X	X	X				X			
ACTIVATION OF DUCT-MOUNTED SMOKE DETECTOR ASSOCIATED WITH MAIN AHU UNITS			X							X			X	X			X	
ACTIVATION OF DUCT-MOUNTED SMOKE DETECTOR ASSOCIATED WITH FIRE/SMOKE DAMPERS			X							X			X				X	
ACTIVATION OF TWO (2) CROSS ZONE DUCT-MOUNTED SMOKE DETECTORS			X							X			X	X			X	
ELEVATOR LOBBY SMOKE DETECTOR ON FIRST FLOOR	X			X		X			X	X	X				X			
ELEVATOR LOBBY SMOKE DETECTOR OTHER THAN FIRST FLOOR	X			X	X				X	X	X				X			
ELEVATOR MECHANICAL ROOM SMOKE DETECTOR	X			X	X			X	X	X	X				X			
ELEVATOR MECHANICAL ROOM THERMAL DETECTOR				X			X											
TOP OF ELEVATOR SHAFT SMOKE DETECTOR								X										
TOP OF ELEVATOR SHAFT THERMAL DETECTOR							X											
TROUBLE CONDITION												X						X
ACTIVATION OF SPRINKLER SYSTEM TAMPER SWITCH													X				X	

As shown by the SOO, there are three different types of signal that can be produced by the fire alarm system: trouble, supervisory, and alarm signals.

The types of inputs that produce trouble signals is not clearly identified by the SOO, which labels "trouble condition" as the only corresponding input. A trouble signal in this system is any type of signal that represents that equipment is not responding as intended, except not in an alarm mode. This could be a fault in the system's wiring, an initiating or notification device malfunctioning, primary power failure, or another similar indication of poor electrical connection. Trouble signals produced by the MCS Building alarm system are transmitted to a central station in accordance with NFPA 72 Section 10.15.7, and are annunciated as trouble signals at the fire alarm annunciation panel. Upon the receipt of a trouble signal, or other signals pertaining solely to matters of equipment maintenance of the fire alarm system, the central station will do the following (NFPA 72 Section 26.3.8.4):

- Communicate directly and immediately with the subscriber
- Dispatch personnel to arrive within 4 hours to initiate maintenance, if necessary

- When the interruption is more than 8 hours, provide notice to the subscriber and the fire department as to the nature of the interruption, the time of occurrence, and the restoration of service

The types of inputs that produce supervisory signals are signals from fire sprinkler systems or other equipment that something about their operational status has changed, but not something that indicates the presence of a fire. In the case of the MCS Building, the type of input that produces a supervisory signal includes activation of the duct smoke detectors in the building, or activation of the fire sprinkler system tamper switch. These two inputs qualify as supervisory signal initiators because smoke detected by the duct smoke detectors could be coming from outside the building, not necessarily inside, and thus should be annunciated as supervisory signals. Activation of the fire sprinkler system tamper switch means that the fire sprinkler system could be impaired, but there is no evidence of fire detected, and thus this should be annunciated as a supervisory signal. Supervisory signals produced by the MCS Building alarm system are transmitted to a central station in accordance with NFPA 72 Section 10.14.1, and are annunciated at the fire alarm annunciation panel as supervisory signals. Upon the receipt of a supervisory signal, the central station will do the following (NFPA 72 Section 26.3.8.3):

- Communicate directly and immediately with the subscriber and notify the fire department
- Dispatch a runner or maintenance person to arrive within 2 hours to investigate, unless the supervisory signal is cleared in accordance with a scheduled procedure (NFPA 72 Section 26.3.8.3(1))
- Notify the AHJ when sprinkler systems or other equipment has been wholly or partially out of service for 8 hours
- When service has been restored, provide notice to the subscriber and AHJ as to the nature of the signal, the time of occurrence, and the restoration of service when equipment has been out of service for 8 hours

The types of inputs that produce alarm signals include any signals initiated by manual pull stations, fire detectors such as area smoke and heat detectors, waterflow from fire sprinkler systems, or other signals that indicate evidence of a fire. In the case of the MCS Building, activation of any area smoke or heat detector, activation of the sprinkler waterflow switch, and activation of any pull station initiates an alarm signal. Any of these inputs qualifies as an alarm signal since they all indicate the presence of a fire or evidence of a fire. Alarm signals produced by the MCS Building fire alarm system are transmitted to a central station in accordance with NFPA 72 Section 26.3.8, and result in the activation of the building’s notification appliances in accordance with NFPA 72 Section 10.12.1. Upon receipt of an alarm signal, the central station will do the following (NFPA 72 Section 26.3.8.1):

- Retransmit the alarm to the emergency communications center
- Dispatch a runner or technician to the protected premises to arrive within 2 hours after receipt of a signal if equipment needs to be manually reset by the contractor
- Immediately notify the subscriber and AHJ

Emergency mass notification signals and messages will be permitted to take precedence over fire alarm, supervisory, and trouble signals in accordance with the requirements of NFPA 72 Chapter 24. Fire alarm signals take precedence over supervisory and trouble signals. Supervisory signals take precedence over trouble signals (NFPA 72 Section 10.7).

17. Fire Alarm Control Panel

The fire alarm control panel used for the MCS Building fire alarm system is the XLS Firefinder model, manufactured by Siemens. This panel meets the UL 2572 standard for in-building mass notification. It supports integrated digital voice signals, which is required to interface with the emergency voice/alarm system installed in the building. It has a capacity of 200 notification appliance circuits (NACs), with up to 3 amps 24VDC per NAC. It supports pre-alarm operation and positive alarm sequencing.

The panel includes sub-assemblies including person machine interface (PMI), device loop cards (DLC), zone indicating cards (ZIC-4A), network interface cards (NIC-C), multi-point digital alarm communicator transmitters (MDACT), and system status display (SSD). The fire alarm panel also includes power supply extenders (PSX-12), since the available 3 amps per NAC is not sufficient to supply the NACs used in the MCS Building. These PSX-12 assemblies support up to 12 amps per NAC, which is sufficient to support the NACs used in the MCS Building.

18. Initiating Devices

The initiating devices utilized as part of the fire alarm system in the MCS Building include manual pull stations, area smoke detectors, and duct smoke detectors. The fire sprinklers used in the suppression system also interconnect with the fire alarm system, and qualify as part of the detection system since they are fixed temperature heat detectors. As discussed in the suppression systems section of this report, waterflow monitoring devices are included in the suppression system and are mounted on the riser. Activation of these waterflow monitoring devices also activates the fire alarm system in accordance with NFPA 72 Section 26.3.8.1.1.

18.1. Manual Fire Alarm System

The offices, medical exam rooms, and research rooms (Group B Occupancies) in the MCS Building are not required to be equipped throughout with a manual fire alarm system, since the building is fully sprinklered (PBCC Section 907.2.2). However, a minimum of one manual fire alarm box is required to be provided (PBCC Section 907.2). According to NFPA 72 Section 17.14.8.4, manual fire alarm boxes will be located within 5 ft. of each exit doorway on each floor. The MCS Building has a manual fire alarm box installed within 5 ft. outside of the doorway to each interior exit stairway, and is in compliance with this requirement. The type of manual fire alarm box used is the HMS-D model, manufactured by Siemens.

The manual fire alarm boxes in the MCS Building installed between 42 in. and 48 in. of the finished floor, located in a conspicuous, unobstructed, and accessible manner, and are red in color, in accordance with NFPA 72 Section 17.14.

A manual fire alarm system installed in accordance with PBCC Section 907.5 is required in the southwest corner of the concourse floor (Group I-2 Occupancy, PBCC Section 907.2.6). The manual fire alarm box installed outside the southwest stairway in this area satisfies this requirement.

Figure 11, Figure 12, Figure 13, and Figure 14 below illustrate the locations of the pull stations throughout the MCS Building.

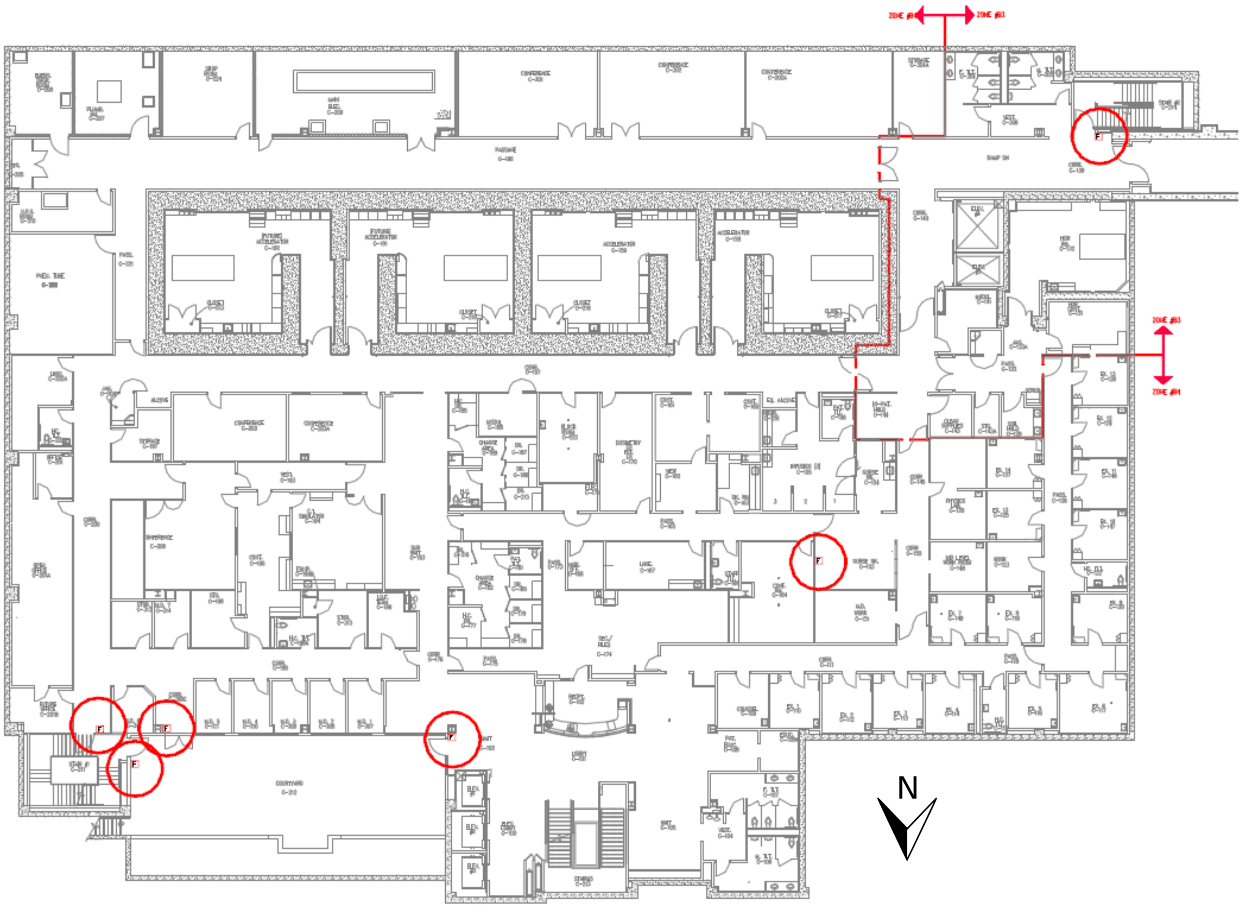

Figure 11. Concourse floor pull station locations

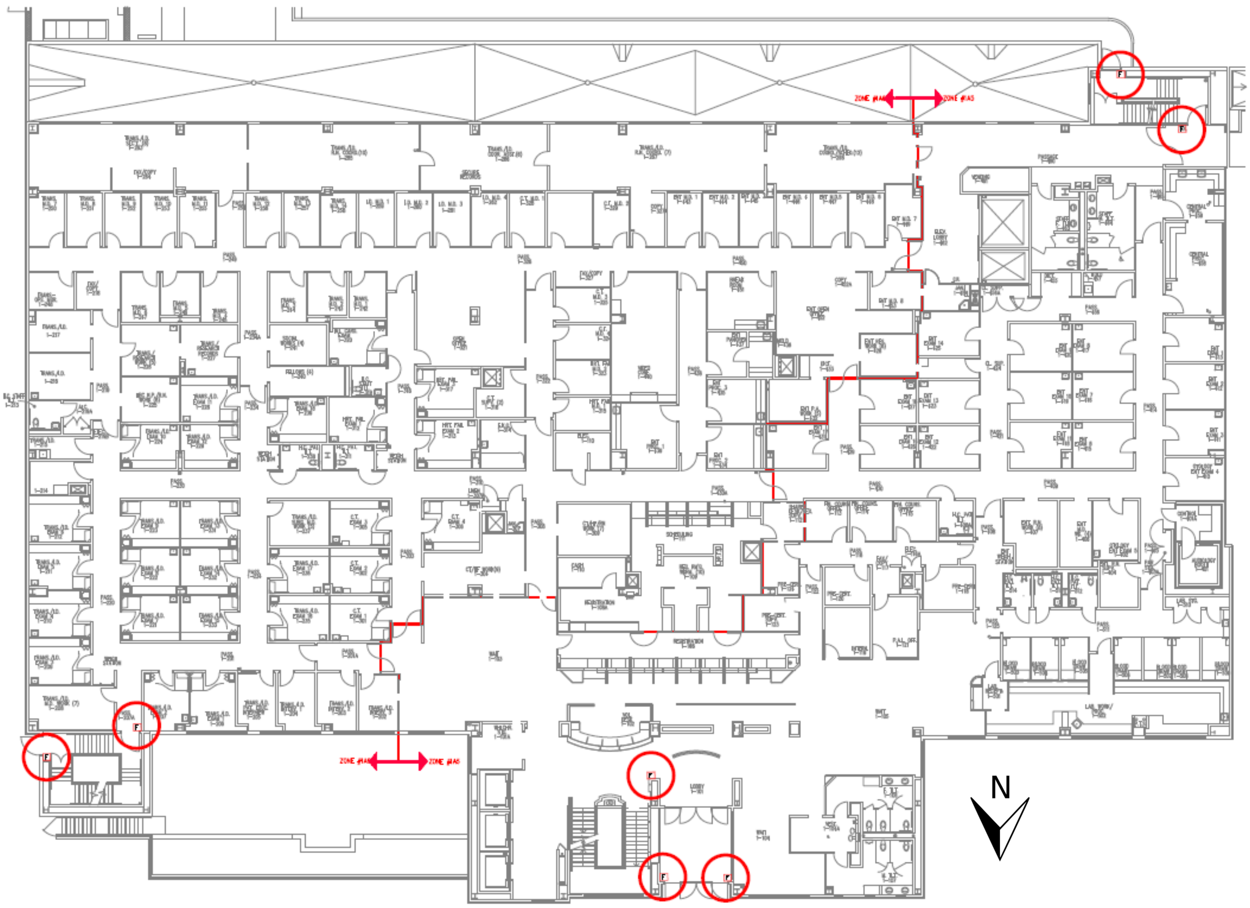

Figure 12. First floor pull station locations

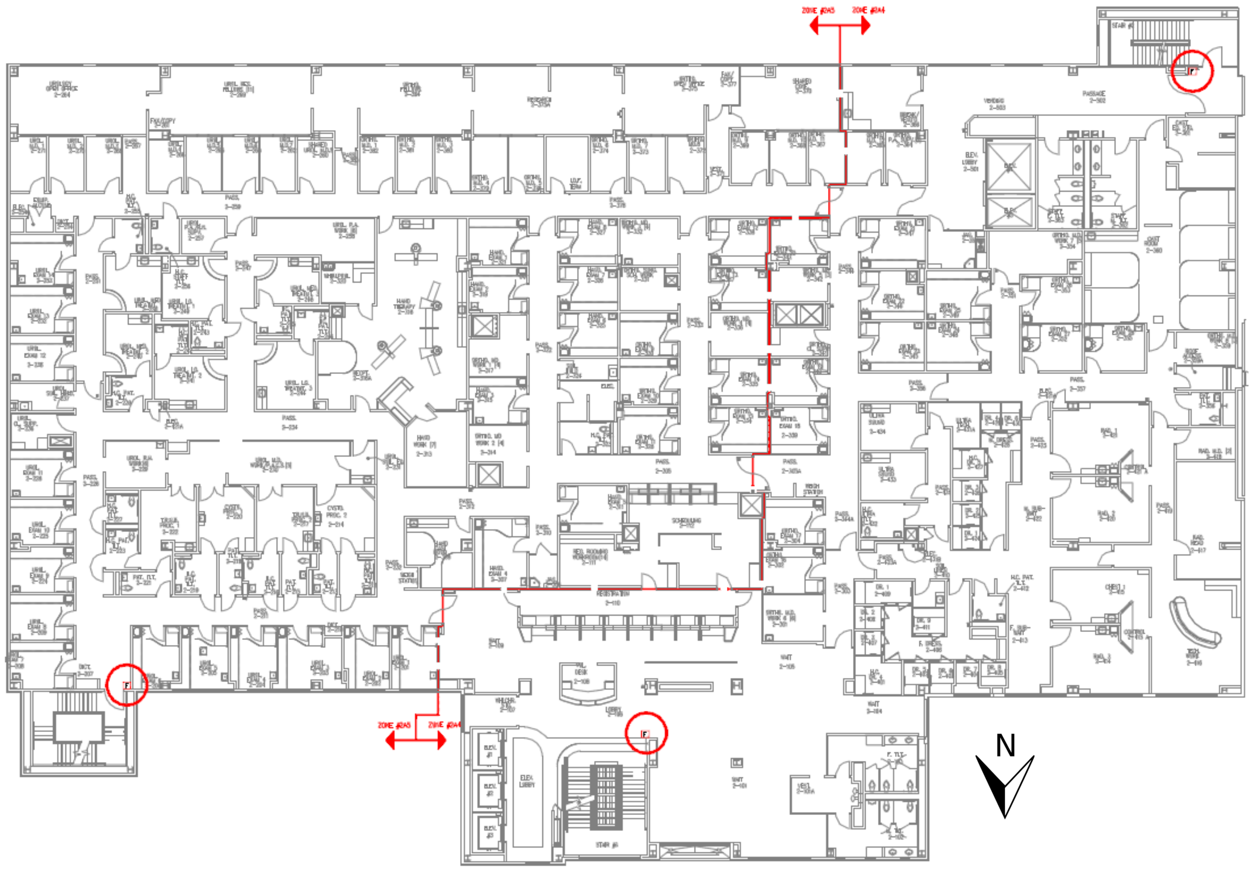

Figure 13. Second floor pull station locations

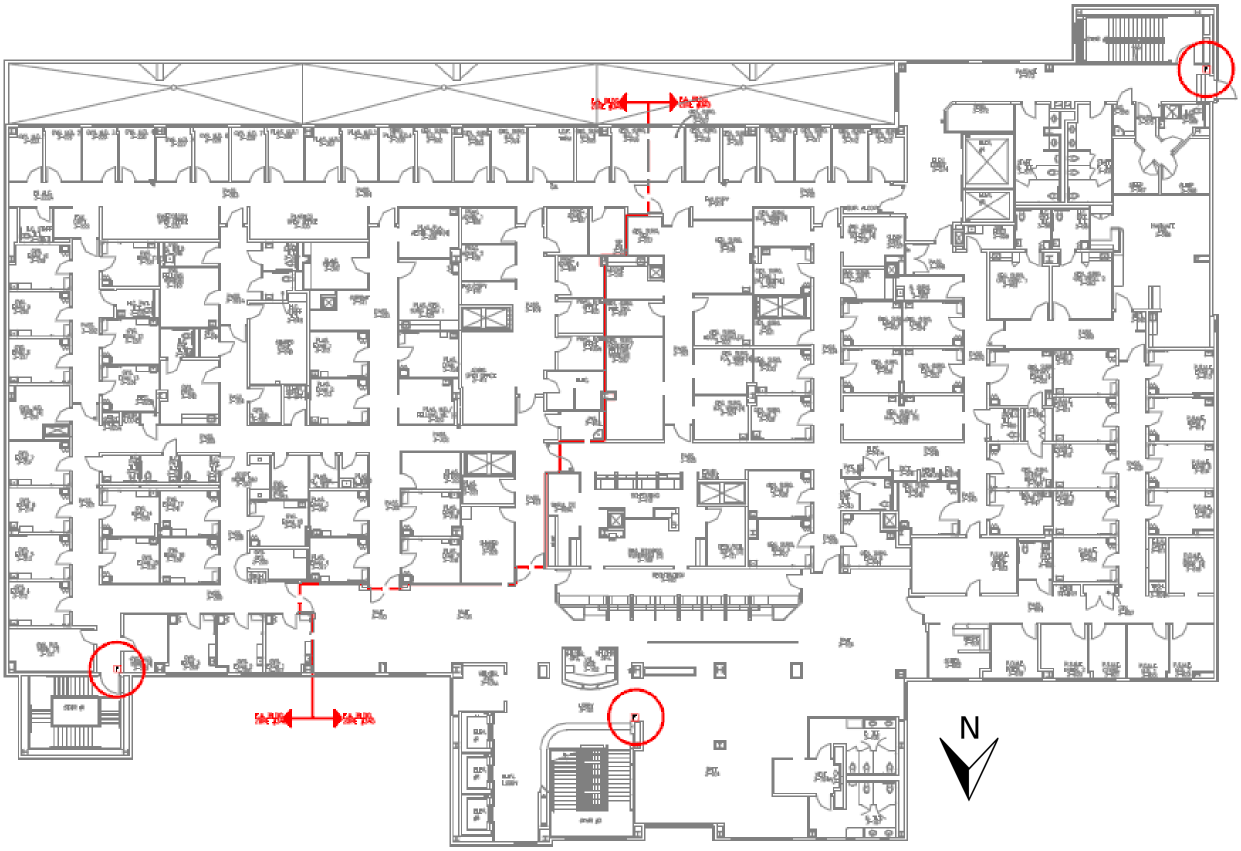

Figure 14. Third floor pull station locations

18.2. Area Smoke Detection

An automatic smoke detection system that activates the occupant notification system is required in the southwest corner of the concourse floor (Group I-2 Occupancy, PBCC Section 907.2.6). A single smoke detector will be provided at the location of each fire alarm control unit (PBCC Section 907.4.1).

The MCS Building is equipped with automatic smoke detectors throughout the southwest corner of the concourse floor. The type of smoke detector used is the HFP-11 photoelectric model, manufactured by Siemens. The detectors are spaced in accordance with the requirements of NFPA 72 Section 17.7.3.2, on a nominal 30 ft. spacing with detectors located within one-half the nominal 30 ft. distance to all walls, measured at right angles.

The MCS Building is also equipped with area smoke detectors in the UPS room, the main electrical room, the plumbing room, the emergency switchgear room, and the miscellaneous storage rooms scattered throughout the building. The type of smoke detector used in these spaces is also the HFP-11 photoelectric smoke detector.

The automatic-closing doors in the horizontal exits in the MCS Building activate upon actuation of smoke detectors in accordance with PBCC Section 716.5.9.3. The smoke detectors used for this door release service are positioned in accordance with the requirements of NPFA 72 Section 17.7.5.6, on either side of the doors, on the centerline of the doorway, no more than 5 ft. measured along the ceiling and perpendicular to the doorway. The smoke detectors used for this application are listed for door release service (NFPA 72 Section 17.7.5.6.3).

The locations of the various area smoke detectors on each floor in the MCS Building are shown below in Figure 15, Figure 16, Figure 17, and Figure 18.

Figure 15. Concourse floor area smoke detector locations

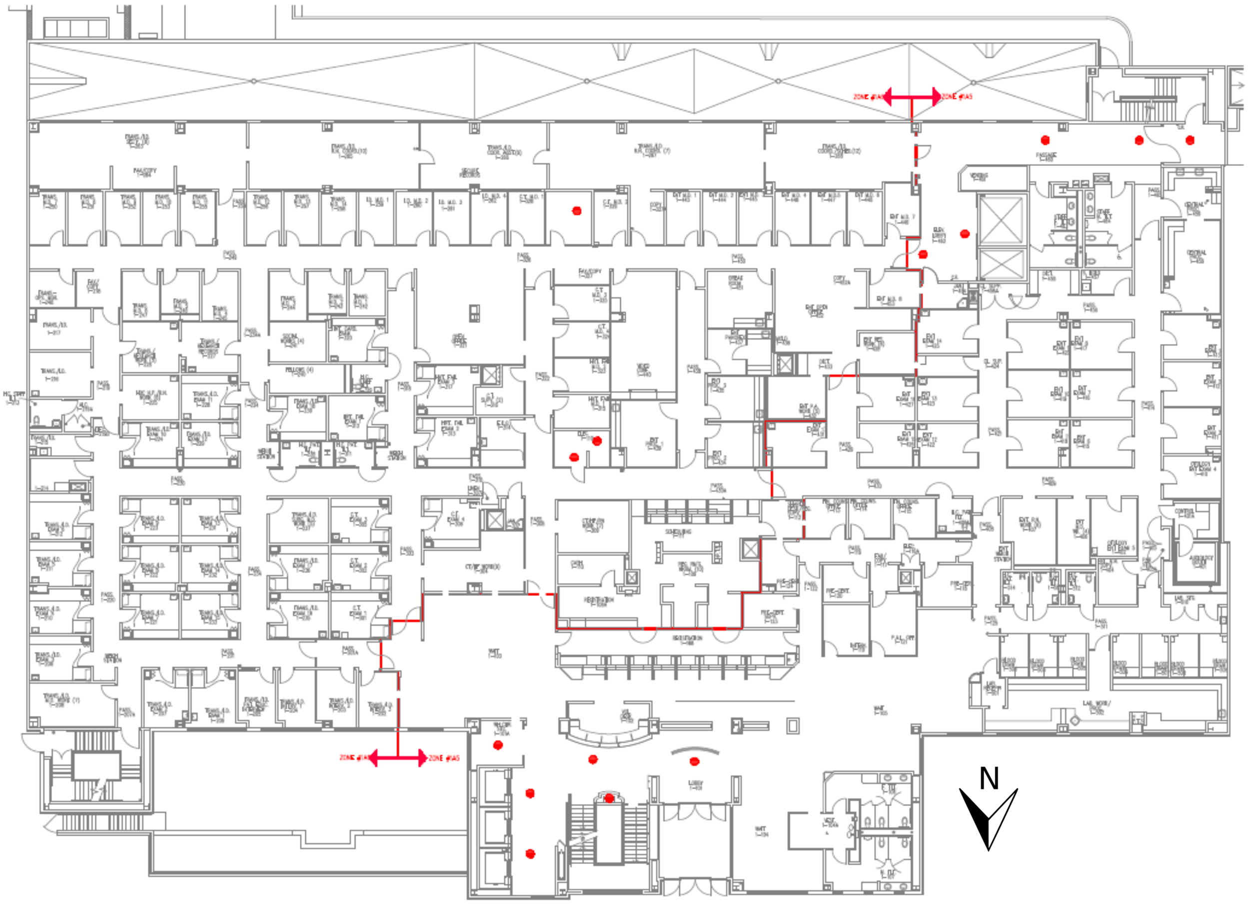

Figure 16. First floor area smoke detector locations

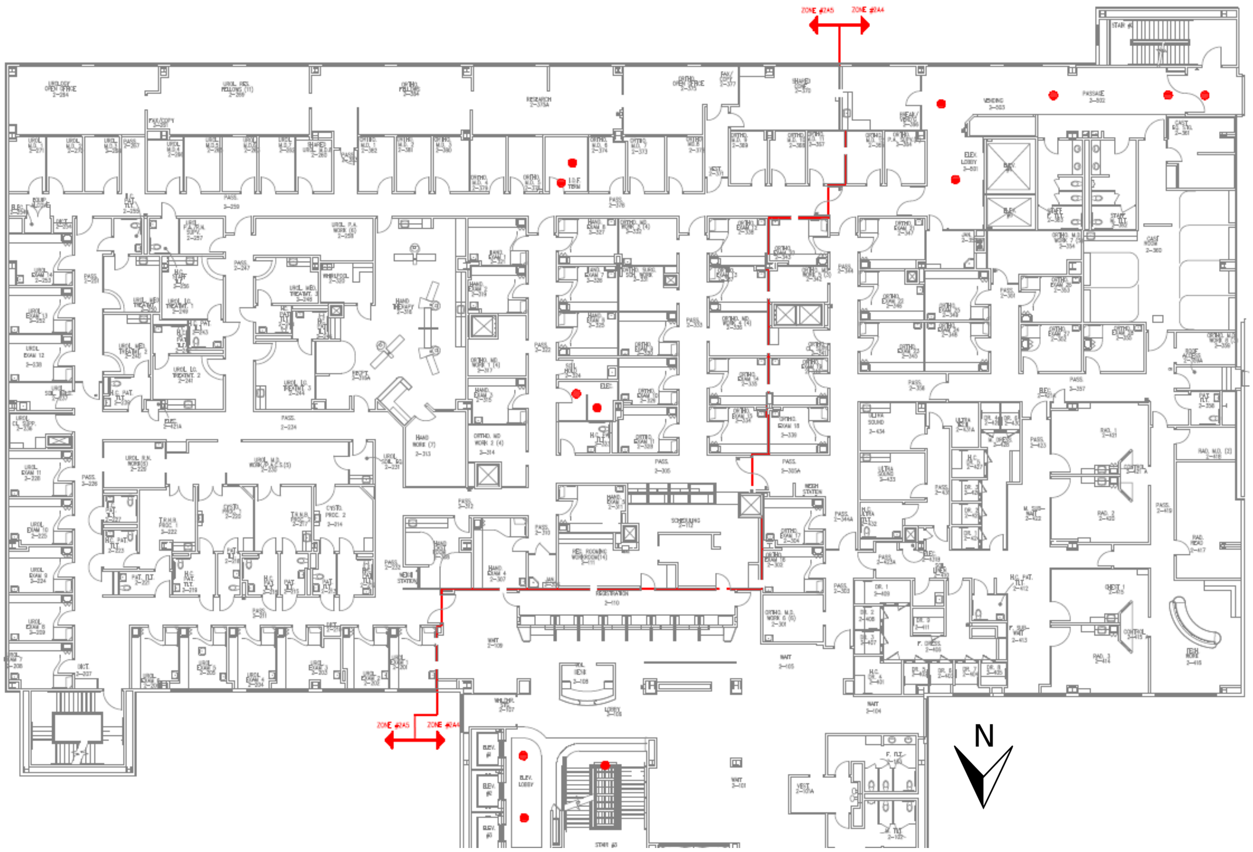

Figure 17. Second floor area smoke detector locations

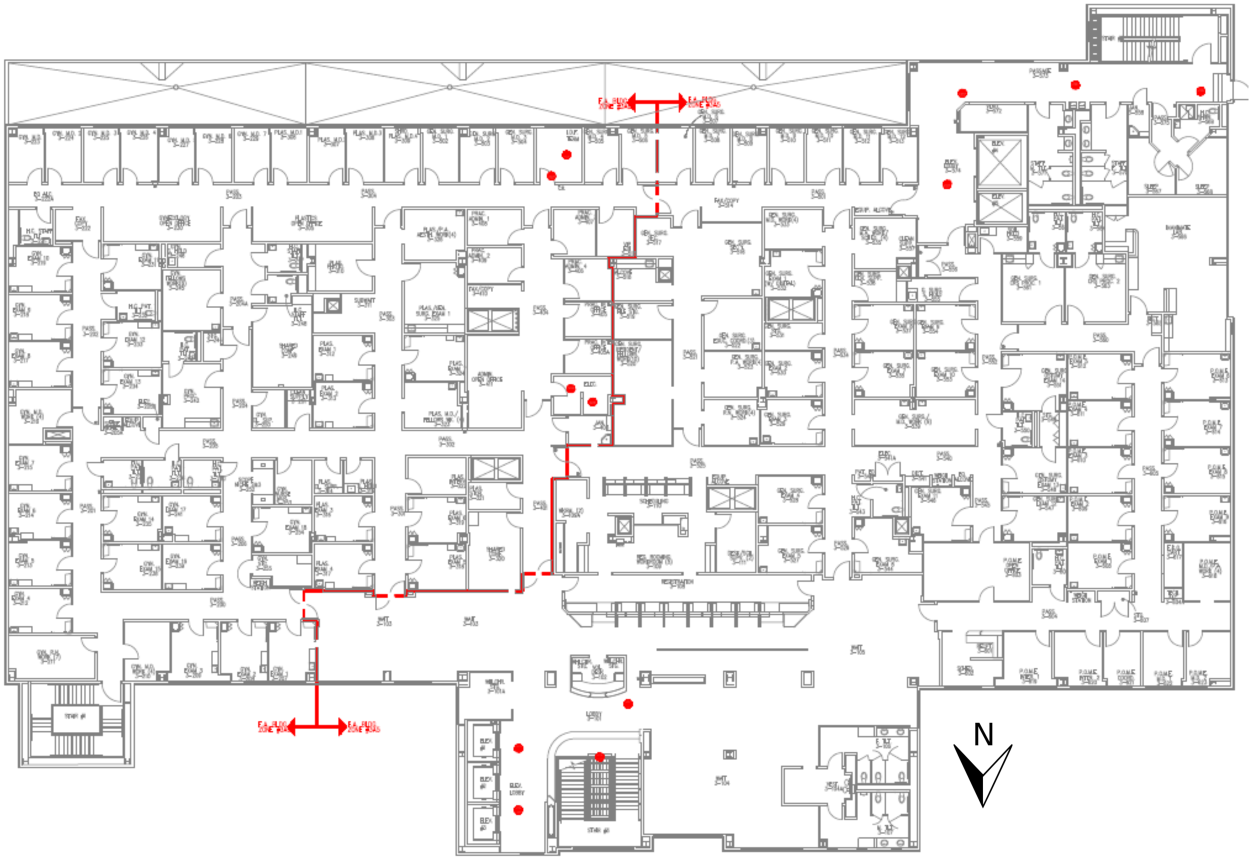

Figure 18. Third floor area smoke detector locations

It should be noted that area smoke detection needs to be provided in the new linear accelerator rooms (machinery spaces) on the concourse level when they are put into service (see Figure 15). The existing linear accelerator rooms are already equipped with area smoke detection.

18.3. Duct Smoke Detection

Duct smoke detectors, listed for the air velocity, temperature, and humidity typically present in the MCS Building, must be installed (PBCC Section 907.3.1). The duct smoke detectors must be connected to the building's fire alarm system, and activation of a duct smoke detector will initiate a visible and audible supervisory signal at a constantly attended location (PBCC Section 907.3.1). Duct smoke detectors will not be used as a substitute for required open area detection (PBCC Section 907.3.1).

Duct smoke detectors are installed throughout the MCS Building. The type of duct smoke detector used is the AD-11P photoelectric model, manufactured by Siemens. The duct smoke detectors are connected to the building's fire alarm system, and upon activation they will initiate a supervisory signal at the fire alarm control panel, initiate a supervisory signal at the central station, and depending on the number of duct smoke detectors activated, they may also initiate smoke management operations (see fire alarm Sequence of Operations matrix, and Smoke Management section of this report).

The duct smoke detectors are installed on the supply side of the air-handling units (AHU) as required by NFPA 72 Section 17.7.5.3.1, as well as on the return side as required by NFPA 72 Section 17.7.5.4.2.2 because total coverage smoke detection is not used in all areas of smoke compartments served by the return air system. Duct smoke detectors are installed in accordance with the manufacturer's recommendations and NFPA 72 Section 17.7.5.5.

19. Notification Devices

Notification devices utilized as part of the fire alarm system for the MCS Building include both audible appliances as well as visible appliances. The particular devices used and their requirements for installation in accordance with NFPA 72 are discussed below.

19.1. Audible Notification Appliances

Alarm notification appliances will be provided and listed for their purpose (PBCC Section 907.5.2). Audible alarm notification appliances will be provided and emit a distinctive sound that is not to be used for any purpose other than that of a fire alarm (PBCC Section 907.5.2.1). Audible alarm notification appliances will provide a sound pressure level of 10 decibels above the average sound level in the building, or 5 decibels above the maximum sound level having a duration of at least 60 seconds, whichever is greater, in every occupiable space within the building (NFPA 72 Section 18.4.4.1). The maximum sound pressure level for audible alarm notification appliances will be 110 decibels at the minimum hearing distance from the audible appliance (PBCC Section 907.5.2.1.2).

Audible alarm notification appliances used in the MCS Building include ceiling-mounted horn/strobes (model number U-MHU-MCS-W), synchronous speaker/strobes (model numbers S-LP70-MCS and S-LP70-MCS-C), and fire alarm speakers (model numbers S-LP70 and S-LP70-C). All of these audible alarm notification devices are manufactured by Siemens. All audible appliances sound with the three-pulse temporal pattern described by NFPA 72 Section 18.4.2.1. The private mode annunciation system is used in the MCS Building, and the private mode audible requirements of NFPA 72 Section 18.4.4 are followed. Audible notification appliances in the building are mounted not less than 90 in. above the finished floor, and not less than 6 in. below the finished ceiling (NPFA 72 Section 18.4.8.1).

As shown in NFPA 72 Table A.18.4.3, the average ambient sound level in business occupancies (which most closely resembles the situation in the MCS Building) is 55 dBA. It is assumed that the maximum sound level having a duration of at least 60 seconds in the building is also 55 dBA, since there is no data available that would indicate otherwise. This means that at minimum, audible notification devices will provide at least 65 dBA (10 dBA above the ambient 55 dBA) sound pressure at any point in the building. At maximum, 110 dBA sound pressure will be provided, at the minimum hearing distance from the audible appliance.

In the shop room, plumbing room, and linear accelerator rooms, sound pressure levels should be at least 95 dBA (10 dBA above 85 dBA, "mechanical rooms" from NFPA 72 Table A.18.4.3).

The Siemens S-LP series speakers and speaker/strobes used in the MCS building produce 75 dBA at ¼ W, 78 dBA at ½ W, 81 dBA at 1 W, and 84 dBA at 2 W (all measured at 10 feet away from the device).

Although the as-built fire alarm plans appear to show that the dBA ratings for audible devices cover every required area in the building, there are a few areas where measurements should be taken to determine if adequate sound pressure is provided. Room C-202, the Pneumatic Tube room, is a machinery space that may need a ½ W speaker instead of ¼ W. Room C-201B, a Future Office, should be equipped with at least a ¼ W speaker when it is divided from the adjoining office to become a separate space. Room 1-440, a Video Conference room, may need a ½ W speaker to be able to provide adequate sound pressure at the far north end of the room. This report does not imply that these rooms are provided with deficient audible notification, only that these areas should be tested with a decibel meter to ensure that adequate sound pressure levels are achieved.

The location of all audible notification appliances on each floor of the MCS Building are shown in the complete fire alarm plans in Appendix H.

19.2. Visible Notification Appliances

Visible alarm notification appliances will be provided in all public areas and common areas (PBCC Section 907.5.2.3.1). Visible alarm notification appliances are not required in exits or elevator cars (PBCC Section 907.5.2.3).

Visible alarm notification appliances used in the MCS Building fire alarm system include the ceiling-mounted horn/strobes and the synchronous speaker/strobes previously mentioned, manufactured by Siemens. The light, color, and pulse characteristics of the visible signals used by these appliances follow the requirements of NFPA 72 Section 18.5.3. The visible notification appliances are mounted such that their lens is between 80 in. and 96 in. above the finished floor (NFPA 72 Section 18.5.5). The spacing of the visible notification appliances is in accordance with NFPA 72 Table 18.5.5.4.1(a) and 18.5.5.4.1(b).

The Siemens S-LP series of speaker/strobes have strobe intensity settings of either 15/75 cd, 30/75 cd, 75 cd, or 110 cd. The maximum candela rating cannot exceed 1000 cd (NFPA 72 Section 18.5.3.4), and the minimum candela ratings for strobes in a room is determined by NFPA 72 Section 18.5.5.4.

The as-built drawings for the MCS Building fire alarm system appear to show candela ratings for visible notification appliances that meet NFPA 72 criteria. However, Room 2-229 Urology Work Room, and Room 3-539 Gen. Surg/Md. Work, may have areas that are not exposed to adequate candela ratings. These areas should be tested in the field to verify that adequate visible notification is provided. When Room C-201B Future Office is divided from the adjoining office, it should be ensured that it is provided with at least a 15 cd rated visible notification appliance.

The location and candela rating of all visible notification appliances on each floor of the MCS Building are shown in the complete fire alarm plans in Appendix H.

20. Smoke Management

Every required exit stairway serving floors more than 75 feet above the lowest level of fire department vehicle access will be a smokeproof enclosure (PBCC Section 403.5.4). Since the MCS Building does not have any floors more than 75 feet above the lowest level of fire department vehicle access, the two interior exit stairways serving the building are not required to be constructed as smokeproof enclosures.

Elevator hoistway pressurization is not required in the building since enclosed elevator lobbies are provided on the concourse level. The first, second, and third floors do not require enclosed elevator lobbies since they are not Group I-2 Occupancies, the elevators do not serve high-rise levels, and the building is sprinklered throughout (PBCC Section 713.14.1, Exception 4).

The 2-hour rated floor-dividing horizontal exits separate each floor of the MCS Building into two different smoke compartments. Each of these smoke compartments serves as a separate HVAC zone. Upon activation of any automatic fire detector in one of these smoke compartments, the fire dampers in the associated zone close, shutting down the return system but keeping the supply and exhaust operating. This will continue to bring fresh air into the zone and exhaust some smoke-contaminated air, helping to dilute the smoke. Shutting down the return prevents smoke-contaminated air from being circulated in the building.

Activation of an area smoke detector or pull station in the second zone served by the floor HVAC system completely and immediately shuts down the air handling unit (AHU). In case smoke manages to use the HVAC system to move between the two smoke compartments on the floor, completely shutting down the AHU prevents it from continuing further.

Any duct smoke detector in the building completely shuts down the HVAC system associated with the floor of detection.

21. Power Supply

Emergency power will be provided for exit signs, means of egress illumination, horizontal sliding doors, elevators, and machine room ventilation (PFC Section 604.2). The MCS Building uses primary power supplied by Arizona Public Service Electric Company (APS). Emergency backup power for the above applications is supplied via UL 2200 listed generators (PFC Section 604.1.1) located in the adjoining hospital.

The primary and secondary power supply for the fire alarm system will be provided in accordance with NFPA 72 (PBCC Section 907.6.2). At least two independent and reliable power supplies will be provided, one primary and one secondary (NFPA 72 Section 10.6.3.2). Each power supply will be of adequate capacity for the application (NFPA 72 Section 10.6.3.3). Power supply integrity will be monitored in accordance with NFPA 72 Section 10.6.9.

21.1. Primary Power Supply

The branch circuit providing primary power to the fire alarm equipment and emergency communication system will supply no other loads and be supplied by commercial light and power (NFPA 72 Section 10.6.5.1). APS supplies primary power in accordance with this requirement.

21.2. Secondary Power Supply

The secondary power system will automatically provide power to the fire alarm and emergency communication systems within 10 seconds whenever the primary power supply fails to provide the minimum voltage required for operation (NFPA 72 Section 10.6.6.1). Storage batteries dedicated to the system are permitted to supply secondary power to ensure required operation (NFPA 72 Section 10.6.6.3.1). The secondary power supply will have sufficient capacity to operate the system under quiescent load for a minimum of 24 hours and then will be capable of operating the system during a fire or emergency condition for a period of 15 minutes at maximum connected load (NFPA 72 Section 10.6.7.2.1, for emergency voice/alarm communication systems). Battery calculations will include a 20 percent safety margin to the calculated amp-hour rating (NFPA 72 Section 10.6.7.2.1[1]). Battery charging will be in accordance with NFPA 72 Section 10.6.10.3.

Batteries serve as secondary power for the MCS Building fire alarm and emergency voice/alarm communication systems. Battery and voltage drop calculations were performed, in order to ensure that the supplied batteries are capable of operating the system under quiescent load for 24 hours and then under an alarm condition for 15 minutes, in accordance with NFPA 72 Section 10.6.7.2.1 for emergency voice/alarm communication systems. A 20 percent safety margin to the calculated amp-hour rating was included.

The summary of the battery and voltage drop calculations is shown below in Table 8 for each fire alarm panel in the MCS Building. The full battery and voltage drop calculations are shown in Appendix I. The Siemens model XLS Firefinder fire alarm panel is used for the main fire alarm control panel on the concourse floor, as well as for the transponder control panels on the first, second, and third floors. A pair of 100 Ah batteries are provided for the main fire alarm control panel on the concourse level, and a pair of 12 Volt, 55 A-hr batteries are provided for each transponder control panel on the other floors (providing a total voltage of 24 V). A safety factor of 20% is applied to the total required A-hr rating (NFPA 72 Section 10.6.7.2.1).

Table 8. Fire alarm system battery and voltage drop calculation summary

Floor	Total Standby (A-hr)	Total Alarm (A-hr)	Total Required A-hr (including safety factor of 20%)
Concourse	55.7	3.4	70.9
First	38.9	3.3	50.7
Second	27.2	3.7	37.0
Third	27.4	3.5	37.0

22. Emergency Voice/Alarm Communication (EVAC) System

The MCS Building is provided with an emergency voice/alarm communication system. Although not required at the initial time of construction, this system was added on later to the building due to the vertical expansion of the adjoining hospital. The vertical expansion caused the adjoining hospital to be classified as a high-rise, and so both the adjoining hospital and the MCS Building were provided with an emergency voice/alarm communication system in accordance with PBCC Section 403.4.4. The objective of the prescriptive portion of this report is to describe the prescriptive fire protection requirements for the MCS Building as a stand-alone building, but since the emergency voice/alarm is an integral part of the MCS building's evacuation procedure, the emergency voice/alarm system will be discussed in this report.

22.1. EVACS Requirements

Emergency voice/alarm communication systems are required to be designed and installed in accordance with NFPA 72 Chapter 24.4.2. The operation of any automatic fire detector, sprinkler waterflow device, or manual fire alarm box will automatically sound an alert tone followed by voice instructions giving approved information and directions for a general or staged evacuation in accordance with the building's fire safety and evacuation plans (PBCC Section 907.5.2.2). Speakers will be provided throughout the building by paging zones, which at a minimum will be provided for elevator groups, exit stairways, each floor, and areas of refuge (PBCC Section 907.5.2.2). A manual override for emergency voice communication will be provided on a selective and all-call basis for all paging zones (PBCC Section 907.5.2.2.1). The emergency voice/alarm communication system will have the capability to broadcast live voice messages by paging zones on a selective and all-call basis (PBCC Section 907.5.2.2.2). The emergency voice/alarm communication system can be used for other purposes, as long as the fire alarm functionality takes precedence over all other uses (PBCC Section 907.5.2.2.3). The emergency voice/alarm communication system will be provided with an approved emergency power source (PBCC Section 907.5.2.2.5).

Evacuation messages will be preceded and followed by a minimum of two cycles of the three-tone temporal evacuation signal (NFPA 72 Section 24.4.2.2.1). The loudspeaker layout of the system will be designed to ensure intelligibility and audibility (NFPA 72 Section 24.4.2.2.2.1).

Undivided fire or smoke areas will not be divided into multiple evacuation signaling zones (NFPA 72 Section 24.4.2.9.1). If multiple notification appliance circuits are provided in a single evacuation signaling zone, all notification appliances will be arranged to activate or deactivate simultaneously (NFPA 72 Section 24.4.2.9.2).

22.2. MCS Building EVACS and Evacuation Procedure

Each floor of the MCS Building is separated into two smoke compartments by a 2-hour rated fire barrier serving as a horizontal exit. Each floor is a single fire alarm zone. Upon activation of an initiating device, a pre-recorded voice message is heard both on the alarm floor, and the floors above and below the alarm floor. The pre-recorded message heard on the alarm floor is "ATTENTION. ATTENTION. A CODE RED CONDITION HAS BEEN IDENTIFIED REQUIRING THE ATTENTION OF STAFF IN THE IMMEDIATE AREA." The pre-recorded message heard on the floors above and below the alarm floor is "ATTENTION. ATTENTION. A CODE RED CONDITION HAS BEEN IDENTIFIED IN AN ADJACENT AREA THAT MAY REQUIRE THE ATTENTION OF STAFF IN THIS AREA. PLEASE STANDBY FOR ADDITONAL INSTRUCTION." These messages are required to be intelligible in accordance with NFPA 72 Section 24.3.1.

The MCS Building EVAC System uses positive alarm sequencing in accordance with NFPA 72 Section 24.4.2.3. The activation of an automatic fire detection device initiates only the strobes on the fire floor, at first. To initiate the positive alarm sequence operation, this signal from an automatic fire detection device must be acknowledged by trained personnel at the fire alarm control unit within 15 seconds of annunciation. If the positive alarm sequence operation is initiated, trained personnel will have 3 minutes to evaluate the fire condition and reset the system if necessary. If the 3 minute window is exceeded, or if the signal is not acknowledged within 15 seconds, the visible notification appliances will continue to operate on the fire floor and will begin to operate on the floors above and below. Audible notification appliances will sound with the pre-recorded messages on the fire floor, and floors above and below, as described previously.

However, if a second automatic fire detection device or pull station is activated before the 3 minute window, the visible and audible notification appliances will immediately begin operating as described, and the pre-recorded messages will sound.

If the waterflow switch is activated, visible and audible notification will be activated immediately on the fire floor and floors above and below, without the positive alarm sequence, and then the pre-recorded messages will sound.

Upon hearing the fire floor pre-recorded message, trained staff will begin staging and evacuating all occupants on the floor. Occupants will be evacuated to the floor below and do not necessarily need to leave the building. Upon hearing the adjacent floor pre-recorded message, trained staff will begin staging occupants for evacuation but will not proceed until they hear the fire floor evacuation message.

Floors other than the fire floor will not hear the evacuation message until an automatic fire detection device activates on the floor, or until the message is initiated at the fire alarm control panel for the floor.

Although the MCS Building does have 2-hour rated horizontal exits on each floor, the building is evacuated on an entire floor basis rather than across floors. This is because the wiring for the EVAC system is not Level 2 or Level 3 pathway survivable, as required by NFPA 72 Section 24.3.6.4.1.

All staff in the MCS Building are trained to react to the pre-recorded messages and activation of the fire alarm system in an appropriate manner. There are no non-ambulatory patients in the building; everyone is expected to be mobile. Staff will guide occupants towards appropriate exits, either the interior exit stairs or the horizontal exits. Staff will check rooms upon evacuation to ensure all occupants have left or are leaving.

The Mayo Clinic Fire Safety Management Plan and employee training description is attached in Appendix J.

23. Fire Alarm System Inspection, Testing, and Maintenance Requirements

The building owner will be responsible to maintain the fire and life safety systems in an operable condition at all times. Service personnel will meet the qualification requirements of NFPA 72 for maintaining, inspecting, and testing such systems (PFC Section 907.8.5).

Access will be provided to each fire alarm device and notification appliance for inspection, testing, and maintenance (PBCC Section 907.6.4).

Devices, equipment, systems, conditions, arrangements, levels of protection, and all other features of the building's fire alarm system will be continuously maintained in accordance with NFPA 72 and as directed by the fire code official (PFC Section 907.8.1). Testing of the fire alarm system and its components will be in accordance with the schedules in NFPA 72 (PFC Section 907.8.2).

Smoke detector sensitivity will be checked within one year after installation and every alternate year thereafter. After the second calibration test, where sensitivity tests indicate that the detector has remained within its listed and marked sensitivity range (or 4-percent obscuration light grey smoke, if not marked), the length of time between calibration tests will be permitted to be extended to a maximum of five years. Where the frequency is extended, records of detector-caused nuisance alarms and subsequent trends of these alarms will be maintained. In zones or areas where nuisance alarms show any increase over the previous year, calibration tests will be performed (PFC Section 907.8.3). Detectors found to have a sensitivity outside the listed and marked sensitivity range will be cleaned and recalibrated or replaced (PFC Section 907.8.4).

Emergency and standby power systems will be maintained in accordance with NFPA 110 and NFPA 111 such that the system is capable of supplying such service within the time specified for the type and duration required (PFC Section 604.3).

Emergency lighting equipment will be inspected and tested in accordance with PFC Section 604.5.

Table 9 below summarizes the requirements from NFPA 72 Chapter 14 for inspection, testing, and maintenance for the MCS Building fire alarm system.

Table 9. MCS Building fire alarm system ITM frequency requirements

Component	Inspection	Testing	Maintenance
All equipment	Annual visual inspection (NFPA 72 Table 14.3.1)	Test components in accordance with NFPA 72 Table 14.4.3.2	Ensure that there are no changes that affect equipment performance, i.e. building modifications, occupancy changes, device location, change in environment, physical obstructions, damage, cleanliness
Control equipment	Fuses, interfaced equipment, lamps and LED's, primary (main) power supply: Annual visual inspection (NPFA 72 Table 14.3.1) Trouble signals: Semiannual visual inspection (NFPA 72 Table 14.3.1)	Functions: Annual test Fuses: Annual test Lamps and LED's: Annual test Primary power supply: Annual test	Verify a system normal condition Verify correct receipt of alarm, supervisory, and trouble signals; circuit supervision; test secondary power system response
Digital alarm communicator transmitter (DACT)	Annual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify location, physical condition, and a system normal condition
Fire emergency voice/alarm communications equipment	Semiannual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify location and condition Test correct receipt of visual and audible signals at control unit
Batteries	Semiannual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Inspect for corrosion, leakage, tightness of connections
Notification appliance circuit power extenders	Annual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify fuse ratings, verify lamps and LED's indicate normal operating status
Duct smoke detectors	Semiannual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify rigid mounting, no penetrations in duct near detector, confirm proper orientation
Waterflow Switch	Quarterly visual inspection (NFPA 72 Table 14.3.1)	Semiannual test	Verify proper operation and installation Test by using inspector's test connection
Manual fire alarm boxes	Semiannual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify proper installation
Smoke detectors	Semiannual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify proper installation Test sensitivity, put into alarm condition and check response at control unit
Supervisory signal devices	Quarterly visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify proper installation Test method depends on type of supervisory component tested
Fire alarm control interface	Semiannual visual inspection (NFPA 72 Table 14.3.1)	Semiannual test	Verify location and condition
Audible appliances	Semiannual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify location and condition Verify operation of notification appliances
Visible appliances	Semiannual visual inspection (NFPA 72 Table 14.3.1)	Annual test	Verify location and condition Verify that each appliance flashes

24. Fire Alarm and Detection System Summary

The fire alarm and detection system, as well as the emergency voice/alarm communication system, are satisfactorily designed in accordance with the requirements of NFPA 72, with only a few minor areas of concern.

This report does not claim that these areas of concern are not designed in accordance with NFPA 72, it only implies that the areas should be inspected and ensured that they are in compliance with NFPA 72. The areas of concern include:

- Room 2-229 and Room 3-539, which should be inspected to confirm that they are provided with adequate candela ratings for visible notification
- Room C-201B, which is not yet divided from the adjoining office. When it is divided in the future, it should be provided with its own visible and audible notification
- The new linear accelerator rooms on the concourse level, which are not yet in service. When they are placed in service, they will require area smoke detectors installed in accordance with the spacing requirements of NFPA 72.

Once the fire alarm and detection system is able to notify occupants, the evacuation process can begin. In order for the evacuation process to be successful, there needs to be an acceptable number of occupants in each space of the building, and adequate egress capacity. The next section of this report discusses the egress system of the MCS Building.

25. Egress System Requirements

The design of the MCS Building egress system is discussed below, including number of exits, location of exits, travel distances, dead ends, stairways, corridors, horizontal exits, and other miscellaneous components. The building's egress system is evaluated for compliance with the provisions of the PBCC.

25.1. Occupancy Separation

Where a building contains two or more occupancies, the means of egress requirements will apply to each portion of the building based on the occupancy of that space. Where two or more occupancies utilize portions of the same means of egress system, those egress components will meet the more stringent requirements of all occupancies that are served (PBCC Section 1004.6). The means of egress in the southwest part of the concourse floor where the Group I-2 Occupancy areas are located will meet the means of egress requirements for Group I-2 Occupancies.

25.2. Number of Exits

Two exits or exit access doorways from any space are provided where the occupant load of the space exceeds one of the values in PBCC Table 1015.1. For Group B Occupancies, the maximum occupant load in this table is 49, and for Group I-2 Occupancies it is 10. The lobby and waiting area on each floor of the building exceeds these limits. On the concourse level, there are three exits provided for the lobby and waiting areas. On the first floor, the lobby and waiting area is provided with six exits. The second floor lobby and waiting area has two exits, and the third floor lobby and waiting area has five exits.

On the concourse level, the only individual room besides the lobby that exceeds these limits is the courtyard, a Group B Occupancy with an occupant load of 117. The courtyard is provided with three exits, one of which leads directly into an interior exit stairway.

Where two or more exits are required, not more than one-half of the total number of exits or total exit width will be horizontal exits (PBCC Section 1025.1). In the lobby areas, none of the provided exits on the concourse level are horizontal exits. One-half of the provided exits for the lobby area on the first, second, and third floors are horizontal exits, so this requirement is met.

The area of each floor east and west of the horizontal exit can be considered as separate spaces, which all exceed the limits in PBCC Table 1015.1. Each one of these areas has two or more exits, and in each case not more than one-half the total number of exits or total exit width is horizontal exits.

Three exits or exit access doorways are provided from any space with an occupant load of 501 to 1,000 (PBCC Section 1015.1.1). No individual room or space east/west of the division provided by the horizontal exit exceeds an occupant load of 500.

Three exits will be provided from any story with an occupant load between 501 and 1,000 (PBCC Section 1021.2.4). Each floor of the building has an occupant load between 501 and 1,000 persons. Three exits are provided for each floor (except the first floor), including two interior exit stairways on every floor, and a horizontal exit on the west end of the building. The first floor also has the main building exit, which is its fourth exit. The west horizontal exit on each floor does not count for more than one-half of the required number of exits or exit width on any floor (PBCC Section 1025.1).

Two exit access doorways are provided in the penthouse boiler room because the floor area exceeds 500 square feet, and the fuel-fired equipment exceeds 400,000 BTU input capacity. The exit access doorways are separated by a horizontal distance equal to one-half the length of the maximum overall diagonal dimension of the boiler room, in accordance with PBCC Section 1015.3.

Each story above the second story of a building must have a minimum of one interior or exterior exit stairway, and at each story above the second story that requires a minimum of three or more exits, a minimum of 50 percent of the required exits will be interior or exterior exit stairways (PBCC Section 1021.1). The third story is the only occupied story above the second floor, and it has two interior exit stairways, which count for two-thirds of its required exits.

Figure 19, Figure 20, Figure 21, and Figure 22 indicate the locations of the exits for each floor of the MCS Building.

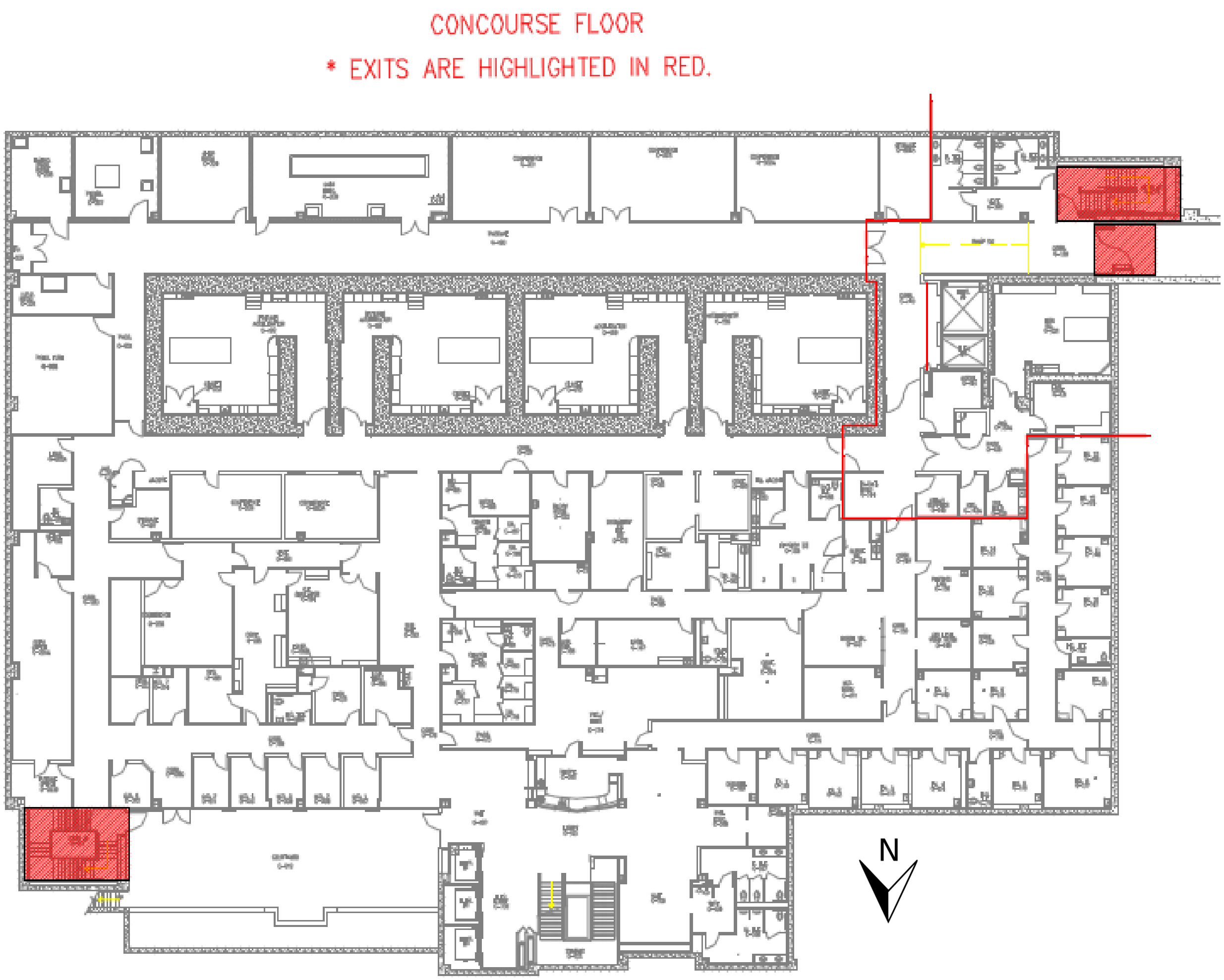

Figure 19. Concourse floor exit locations

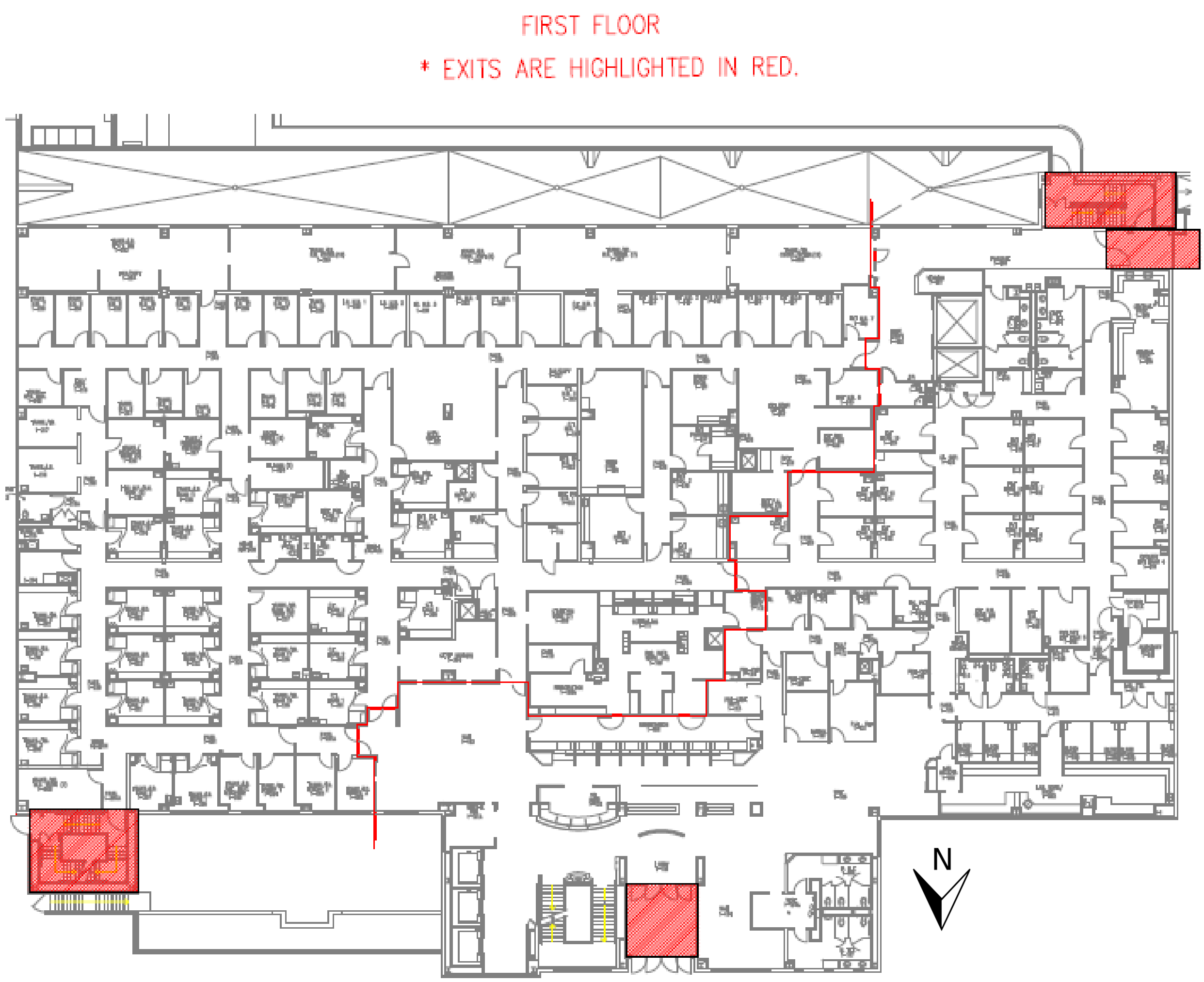

Figure 20. First floor exit locations

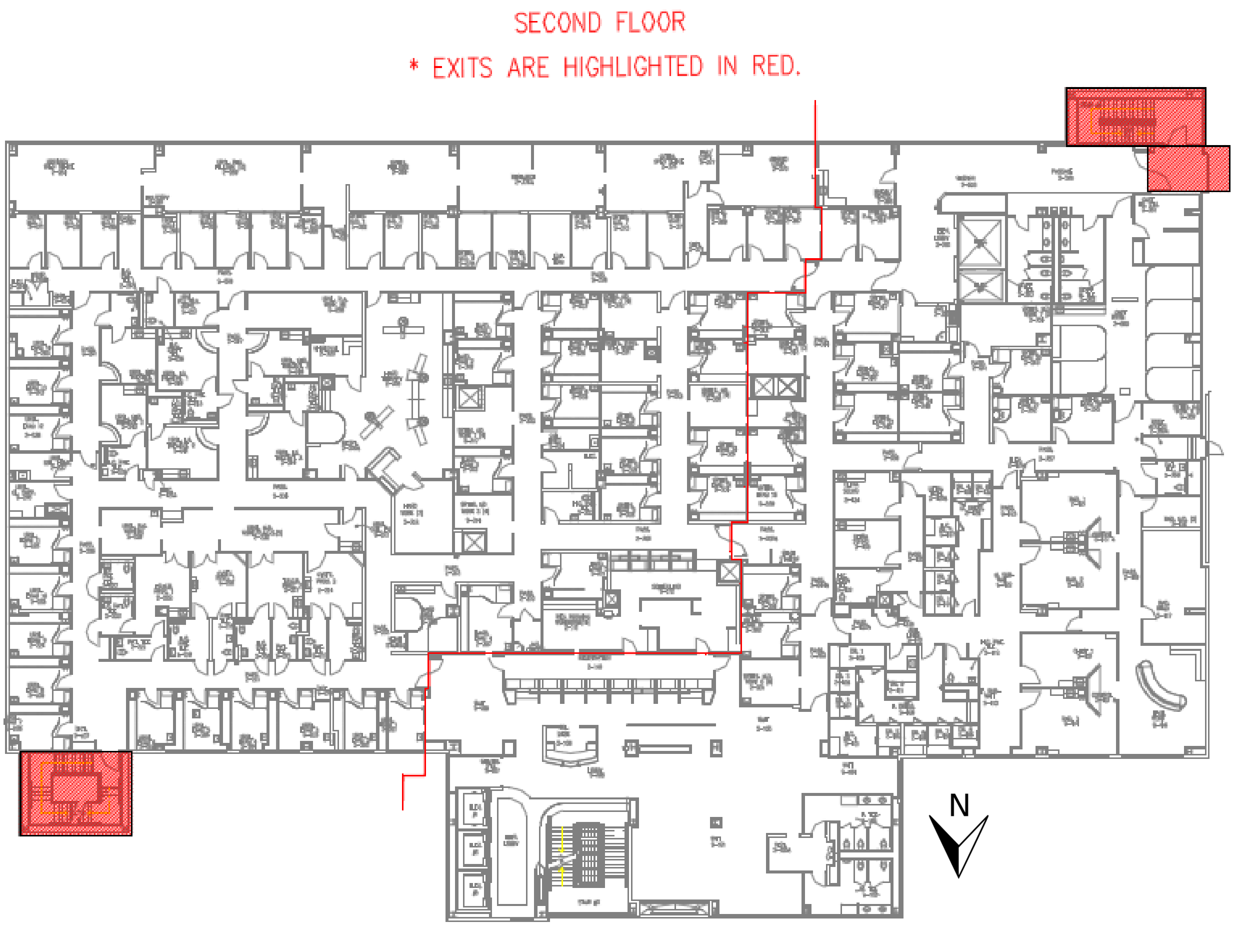

Figure 21. Second floor exit locations

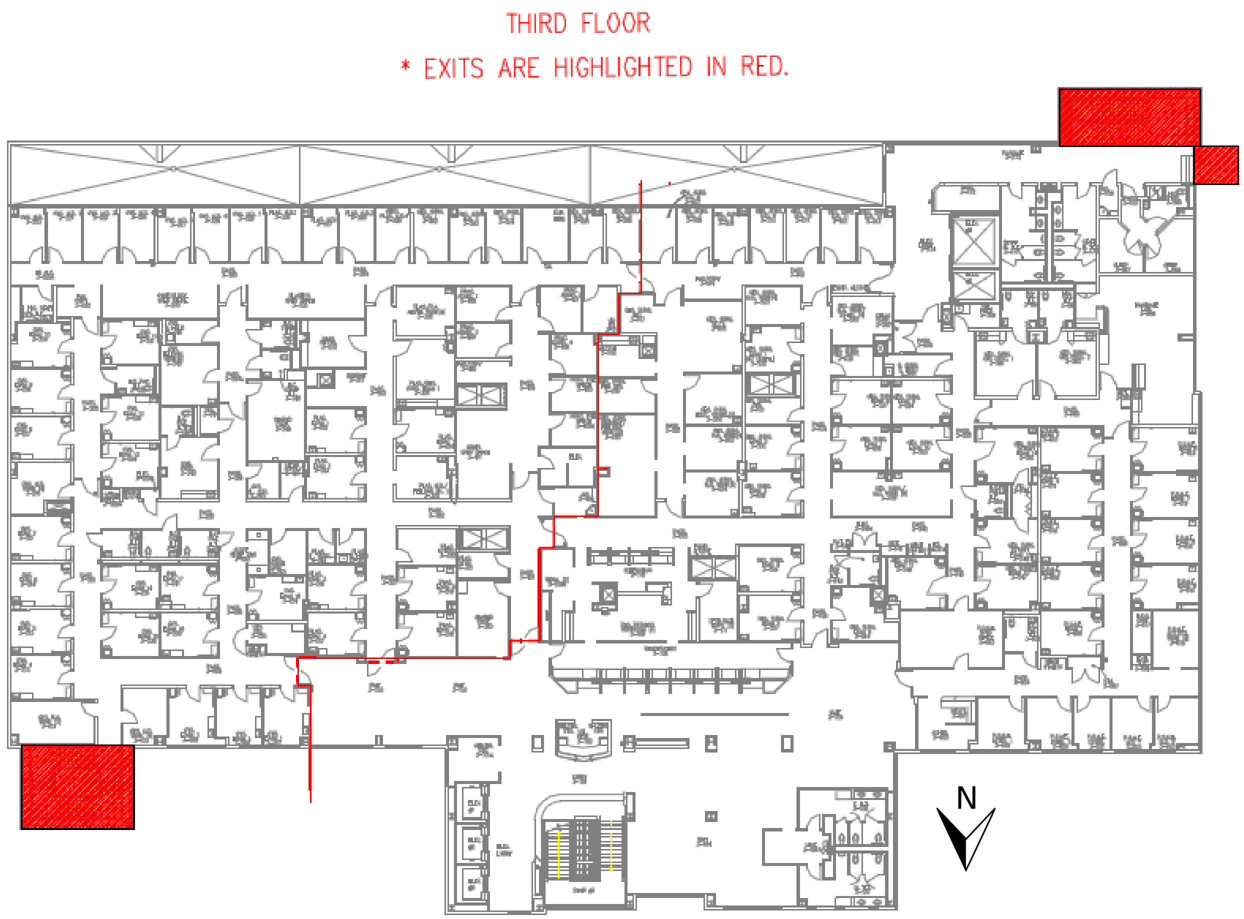

Figure 22. Third floor exit locations

25.3. Location of Exits

Because the MCS Building is fully sprinklered, where two exits or exit access doorways are required from any portion of the exit access, the exit doors or exit access doorways are placed a distance apart equal to not less than one-third of the length of the maximum overall diagonal dimension of the area served (PBCC Section 1015.2.1). Where three exits or exit access doorways are required, two of the exits or exit access doorways are arranged in accordance with the provisions of PBCC Section 1015.2.1.

The concourse courtyard, which is the only individual room requiring two exits, has a diagonal of 72 feet. The two farthest apart exits are 69 feet apart, which is greater than the required 24 feet. Therefore, the courtyard complies with the requirements of PBCC Section 1015.2.1.

The separated areas east and west of the horizontal exit on each floor, each of which require two exits, have diagonals of roughly 240 feet. The farthest south access to the horizontal exit and the northeast interior stairway are located on opposite ends of the diagonal in the areas east of the horizontal exit. The farthest north access to the horizontal exit dividing the floor and the southwest interior stairway are located on opposite ends of the diagonal in the areas west of the horizontal exit. These spaces comply with the exit separation requirements of PBCC Section 1015.2.1.

Where more than one exit, or access to more than one exit, is required, the means of egress will be configured such that the loss of any one exit, or access to one exit, will not reduce the available capacity to less than 50 percent of the required capacity (PBCC Section 1005.5). For the concourse courtyard, loss of one exit reduces available capacity to 360 people, and the required capacity is 117. Note that the exit capacity factor for the southwest stairway on the concourse level is 0.3 inch per person because it is in a Group I-2 Occupancy area, but the other stairways have exit capacity factors of 0.2 inch per person because they are in sprinklered Group B Occupancy areas (PBCC Section 1005.3.1). For the same reason, all means of egress excluding stairways use an exit capacity factor of 0.15 inch per person except for those in the Group I-2 Occupancy area (PBCC Section 1005.3.2). For the areas east and west of the horizontal exit on each floor, and for each entire floor, a summary of the capacity with one exit compromised and the required capacity is given in Appendix K. All rooms, spaces, and floors of the MCS Building comply with the requirements of PBCC Section 1005.5.

Egress from a room or space in the MCS Building does not pass through adjoining or intervening rooms/areas, except where such adjoining rooms or areas and the area served are accessory to one or the other (PBCC Section 1014.2). Egress does not pass through kitchens, storage rooms, closets, or spaces used for similar purposes (PBCC Section 1014.2).

Exits are located in a manner that makes their availability obvious, and will be unobstructed at all times (PBCC Section 1015.2).

Exterior exit doors must lead directly to the exit discharge or the public way (PBCC Section 1020.2.2). The exterior exit doors at the front of the building and at each staircase on the first floor all lead directly to the exit discharge or public way.

Exits will be continuous from the point of entry into the exit to the exit discharge (PBCC Section 1021.3). All exits in the MCS Building comply with this requirement; each interior stairway is continuous from point of entry to exit discharge. The north stairway is not considered an exit for the reason that it is not continuous from the point of entry to the exit discharge. It is normally open to the building, and the divisions between floors are closed with 2-hour rated horizontal sliding fire door assembly in case of fire.

The exit discharge will provide a direct and unobstructed access to a public way (PBCC Section 1027.5). Each exit discharge out of the building is maintained so as to comply with this requirement.

25.4. Exit Travel Distances

The longest common path of egress travel for each floor is shown on the floor plans in Appendix L. According to PBCC Table 1014.3, the longest permissible path of egress travel in a sprinklered Group B Occupancy is 100 feet, and 75 feet in a sprinklered Group I-2 Occupancy. There are no common paths of egress travel on any floor that exceed 71 feet.

Therefore, the MCS Building complies with the PBCC requirements for common path of egress travel.

The longest travel distance within the exit access portion of the means of egress for each floor is shown in Appendix M. The exit access travel distance in a sprinklered Group B Occupancy cannot exceed 300 feet, and cannot exceed 200 feet in a sprinklered Group I-2 Occupancy, in accordance with PBCC Table 1016.2. Therefore, the MCS Building complies with PBCC maximum allowable exit access travel distance requirements.

The longest dead end on each floor of the MCS Building is shown on the plans in Appendix N. Where more than one exit or exit access doorway is required, the exit access is required to be arranged such that there are no dead ends in corridors more than 20 feet in length in Group I-2 Occupancies and 50 feet in length in sprinklered Group B Occupancies (PBCC Section 1018.4). The MCS Building complies with PBCC dead end length requirements.

Habitable rooms in Group I-2 Occupancies will have an exit access door leading directly to a corridor (PBCC Section 407.4.1). The travel distance between any point in a Group I-2 Occupancy sleeping room and an exit access door in that room will not be greater than 50 feet (PBCC Section 407.4.2). Care suites will be separated from other portions of the building by a smoke partition (PBCC Section 407.4.3.2). Exit access from all other portions of the building not classified as a care suite will not pass through a care suite (PBCC Section 407.4.3.1). Care suites not containing sleeping rooms will not be greater than 10,000 square feet in area (PBCC Section 407.4.3.6.1), and any care suite of more than 2,500 square feet in area will have no fewer than two exit access doors from the care suite (PBCC Section 407.4.3.5.2).

The rooms classified as Group I-2 Occupancies on the concourse floor each have an exit access door leading directly to a corridor outside the room. The longest travel distance in one of these rooms to a door is 36 feet. The walls around each Group I-2 Occupancy room are constructed as smoke partitions. No rooms require exit access through these Group I-2 Occupancy rooms. The largest Group I-2 Occupancy room is 570 square feet, which has one exit access door. Therefore, the Group I-2 Occupancy rooms on the concourse floor comply with the requirements of PBCC Section 407.

25.5. Corridors

In Group B Occupancies not listed in PBCC Table 1018.2, required minimum corridor width is 44 inches. In areas of Group I-2 Occupancies where required for bed movement, minimum corridor width is 96 inches (PBCC Table 1018.2). The smallest typical corridor in the Group B Occupancy areas of the MCS Building is 78 inches. The corridors in the Group I-2 Occupancy area of the concourse level are 96 inches wide. The MCS Building complies with PBCC corridor width requirements.

Corridors are required to be fire-resistance rated in accordance with PBCC Table 1018.1 (PBCC Section 1018.1). However, for both sprinklered Group B Occupancies and sprinklered Group I-2 Occupancies, corridors are not required to have a fire-resistance rating. The typical corridor in the MCS Building is not fire-resistance rated. The MCS Building then complies with PBCC requirements for fire-resistance rated corridors.

Corridors in the concourse level Group I-2 Occupancies are continuous to the exits and are separated from other areas by corridor walls constructed as smoke partitions (PBCC Section 407.2).

The minimum width of exit passageways will be not less than 44 inches, except that exit passageways serving an occupant load of less than 50 will not be less than 36 inches in width. The required width of exit passageways will be unobstructed (PBCC Section 1023.2). Exit passageway enclosures will have walls, floors and ceilings of not less than 1 hour fire-resistance rating, and not less than that required for any connecting interior exit stairway. Exit passageways will be constructed as fire barriers in accordance with Section 707 or horizontal assemblies constructed in accordance with Section 711, or both (PBCC Section 1023.3). The smallest exit passageway width in the MCS Building is 78 inches, and all corridors are constructed to the PBCC Section 707 requirements for fire barriers and PBCC Section 1023 requirements for exit passageways, including 1-hour fire-resistance ratings.

Penetrations into and openings through an exit passageway are prohibited except for required exit doors, equipment and ductwork necessary for independent pressurization, sprinkler piping, standpipes, electrical raceway for fire department communication and electrical raceway serving the exit passageway and terminating at a steel box not exceeding 16 square inches. Such penetrations are protected in accordance with Section 714 (PBCC Section 1023.6).

The means of egress is illuminated at all times the building space served by the means of egress is occupied (PBCC Section 1006.1). In the event of power supply failure, an emergency electrical system will automatically illuminate the MCS Building corridors (PBCC Section 1006.3). The emergency power system will provide power for a duration of not less than 90 minutes and will consist of storage batteries, unit equipment or an on-site generator (PBCC Section 1006.3). A generator system located in the adjoining hospital provides emergency power.

In sprinklered Group B Occupancies, the interior wall and ceiling finish is required to be Class B for exit passageways and Class C for corridors (PBCC Table 803.9). In sprinklered Group I-2 Occupancies, the interior wall and ceiling finish is required to be Class B for exit passageways and Class B for corridors (PBCC Table 803.9). The corridors in the Group B Occupancy areas use Class C interior finish, and the exit passageways use Class B interior finish. Class B interior finish is used throughout the Group I-2 Occupancy area. The MCS Building complies with PBCC requirements concerning interior finish in exit passageways and corridors.

In all occupancies, interior floor finish and floor covering materials in enclosures for exit passageways and corridors not separated by partitions extending from the floor to the underside of the ceiling will withstand a minimum critical radiant flux. The minimum critical radiant flux will not be less than Class II in sprinklered Group I-2 Occupancies, and not less than DOC FF-1 “pill test” or ASTM D 2859 compliant in Group B Occupancies (PBCC Section 804.4.2). In the MCS Building, interior floor finish throughout is Class II, so it is in compliance with the PBCC requirements.

25.6. Stairways

Interior exit stairways terminate at an exit discharge or a public way (PBCC Section 1022.3). Exits discharge directly to the exterior of the building. The exit discharge is at grade or provides direct access to grade. A maximum of 50 percent of the number and capacity of interior exit stairways is permitted to egress through areas on the level of exit discharge provided that the conditions of PBCC Section 1027.1 are met. This does not occur for either of the two interior exit stairways in the building.

Enclosures for interior exit stairways are constructed as fire barriers in accordance with PBCC Section 707 or horizontal assemblies in accordance with PBCC Section 711, or both. Both interior exit stairway enclosures have a fire-resistance rating of not less than 2 hours because each connects four stories or more. Interior exit stairways have a fire-resistance rating not less than the assembly penetrated, which is a 2-hour rating in the case of the ceiling assemblies in the building (PBCC Section 1022.2).

Openings in interior exit stairways other than unprotected exterior openings are limited to those necessary for exit access to the enclosure from normally occupied spaces and for egress from the enclosure (PBCC Section 1022.4).

Penetrations into and openings through interior exit stairways are prohibited except for required exit doors, equipment and ductwork necessary for independent ventilation or pressurization, sprinkler piping, standpipes, electrical raceway for fire department communication systems and electrical raceway serving the interior exit stairway and terminating at a steel box not exceeding 16 square inches. Such penetrations are protected in accordance with PBCC Section 714 (PBCC Section 1022.5).

Exterior walls of the interior exit stairways comply with the requirements of PBCC Section 705 for exterior walls. Where nonrated walls or unprotected openings enclose the exterior of the stairway and the walls or openings are exposed by other parts of the building at an angle of less than 180 degrees, the building exterior walls within 10 feet horizontally of a nonrated wall or unprotected opening must have a fire-resistance rating of not less than 1 hour. Openings within such exterior walls must be protected by opening protective having a fire-resistance rating of not less than ¾ hour. This construction extends vertically from the ground to a point 10 feet above the topmost landing of the stairway or to the roof line, whichever is lower (PBCC Section 1022.7). However, there are no nonrated walls around the interior stairways, so the MCS Building complies with these requirements.

An interior exit stairway will not continue below its level of exit discharge unless an approved barrier is provided at the level of exit discharge to prevent persons from unintentionally continuing into levels below (PBCC Section 1022.8). The interior exit stairways in the MCS Building all contain barriers at the first floor (the level of exit discharge) that satisfy this requirement.

The capacity of means of egress stairways will be calculated by multiplying the occupant load served by such stairway by a means of egress capacity factor of 0.3 inch per occupant. Where stairways serve more than one story, only the occupant load of each story considered individually will be used in calculating the required capacity of the stairways serving that story (PBCC Section 1005.3.1). For sprinklered Group B Occupancies, the means of egress capacity factor for stairways is 0.2 inch per occupant. A summary of the exit capacities of each space, stairway, and exit in the building is given in Appendix K.

The interior exit stairways all lead directly to the exterior of the building (PBCC Section 1009.2). All interior exit stairways are enclosed in accordance with PBCC Section 1022, and floor openings between stories created by exit access stairways are enclosed (PBCC Section 1009.3).

Where a stairway is provided to a roof, access to the roof will be provided through a penthouse complying with PBCC Section 1509.2. Roofs and penthouses containing elevator equipment that must be accessed for maintenance are required to be accessed by a stairway (PBCC Section 1009.17). These requirements are met by the MCS Building through its mechanical penthouse, accessed by the southwest stairway.

The stairways used as means of egress are illuminated at all times when the building is occupied (PBCC Section 1006.1). In the event of power supply failure, an emergency electrical system will automatically illuminate interior exit stairways (PBCC Section 1006.3). The emergency power system will provide power for a duration of not less than 90 minutes and will consist of an on-site generator, located in the adjoining hospital (PBCC Section 1006.3).

In sprinklered Group B Occupancies, the interior wall and ceiling finish is required to be Class B for interior exit stairways (PBCC Table 803.9). In sprinklered Group I-2 Occupancies, the interior wall and ceiling finish is required to be Class B for interior exit stairways (PBCC Table 803.9).

In all occupancies, interior floor finish and floor covering materials in enclosures for stairways not separated from corridors by partitions extending from the floor to the underside of the ceiling will withstand a minimum critical radiant flux. The minimum critical radiant flux will not be less than Class II in sprinklered Group I-2 Occupancies, and not less than DOC FF-1 “pill test” or ASTM D 2859 compliant in Group B Occupancies (PBCC Section 804.4.2). In the MCS Building, interior floor finish throughout is Class II, as previously discussed.

25.7. Horizontal Exits

The separation between buildings connected by a horizontal exit will be provided by a fire wall complying with Section 706, or by a fire barrier complying with Section 707 or a horizontal assembly complying with Section 711, or both. The minimum fire-resistance rating of the separation will be 2 hours. Opening protective in horizontal exits will also comply with Section 716. The horizontal exit separation will extend vertically through all levels of the building unless floor assemblies have a fire-resistance rating of not less than 2 hours with no unprotected openings (PBCC Section 1025.2). The horizontal exit on each floor of the MCS Building is constructed as a fire barrier complying with Section 707, with a 2-hour fire-resistance rating. The floor assemblies have a 2-hour fire-resistance rating with no unprotected openings, so the horizontal exit separation does not extend vertically in the same locations through all levels of the building.

Fire doors in horizontal exits are self-closing or automatic-closing when activated by a smoke detector in accordance with Section 716.5.9.3. Doors, where located in a cross-corridor condition, are automatic-closing by activation of a smoke detector in accordance with Section 716.5.9.3 (PBCC Section 1025.3).

The refuge area of a horizontal exit will be a space occupied by the same tenant or a public area and each such refuge area will be adequate to accommodate the original occupant load of the refuge area plus the occupant load anticipated from the adjoining compartment. The anticipated occupant load from the adjoining compartment will be based on the capacity of the horizontal exit doors entering the refuge area. The capacity of the refuge area will be computed based on a net floor area allowance of 3 square feet for each occupant in Group B Occupancies, and 15 square feet for each occupant in Group I-2 (ambulatory) Occupancies (PBCC Section 1025.4). The refuge areas of the horizontal exits in the building are all able to accommodate the required occupant loads as required by the PBCC.

The adjoining compartment will not be required to have a stairway or door leading directly outside, provided the refuge area into which a horizontal exit leads has stairways or doors leading directly outside and are so arranged that egress will not require the occupants to return through the compartment from which egress originates (PBCC Section 1025.4). The hospital into which the west horizontal exit leads satisfies this requirement.

The capacity of means of egress components other than stairways, including the doors in horizontal exits, are calculated by multiplying the occupant load served by such component by a means of egress capacity factor of 0.2 inch per occupant (PBCC Section 1005.3.2). For sprinklered Group B Occupancies, the means of egress capacity factor is 0.15 inch per occupant.

25.8. Exit Doors and Exit Signs

The minimum width of each door opening is sufficient for the occupant load thereof and will provide a clear width of 32 inches. Means of egress doors in a Group I-2 Occupancy used for the movement of beds will provide a clear width not less than 41 ½ inches. The height of door openings is not less than 80 inches (PBCC Section 1008.1.1).

The minimum space between two doors in a series is 48 inches minimum plus the width of a door swinging into the space. Doors in a series swing either in the same direction or away from the space between the doors (PBCC Section 1008.1.8). Egress doors are readily open-able from the egress side without the use of a key or special knowledge or effort (PBCC Section 1008.1.9).

Exits and exit access doors is marked by an approved exit sign readily visible from any direction of egress travel. The path of egress travel to exits and within exits is marked by readily visible exit signs to clearly indicate the direction of egress travel in cases where the exit or the path of egress travel is not immediately visible to the occupants. Intervening means of egress doors within exits is marked by exit signs. Exit sign placement is such that no point in an exit access corridor or exit passageway is more than 100 feet or the listed viewing distance for the sign, whichever is less, from the nearest visible exit sign. Exit signs are not required in rooms that require only one exit or exit access (PBCC Section 1011.1). See Appendix O for floor plans indicating the locations of exit signs in the MCS Building.

Exit signs are illuminated at all times. To ensure continued illumination for a duration of not less than 90 minutes in case of primary power loss, the sign illumination means is connected to an emergency power system provided from an on-site generator, located in the adjoining hospital (PBCC Section 1011.6.3).

26. Miscellaneous Prescriptive Egress Requirements

In the Group I-2 Occupancy area on the concourse floor, curtains, draperies, hangings and other decorative materials suspended from walls or ceilings meet the flame propagation performance criteria of NFPA 701 or are noncombustible (PBCC Section 806.1).

The means of egress has a ceiling height of not less than 7 feet 6 inches, in accordance with PBCC Section 1003.2.

Protruding objects are permitted to extend below the minimum ceiling height, provided a minimum headroom of 80 inches is provided for any walking surface, including walks, corridors, aisles and passageways. Not more than 50 percent of the ceiling area of a means of egress is reduced in height by protruding objects (PBCC Section 1003.3.1).

Structural elements, fixtures or furnishings do not project horizontally from either side more than 4 inches over any walking surface between the heights of 27 inches and 80 inches above the walking surface (PBCC Section 1003.3.3).

Protruding objects do not reduce the minimum clear width of accessible routes (PBCC Section 1003.3.4).

Walking surfaces of the means of egress have a slip-resistant surface and are securely attached (PBCC Section 1003.4).

Where changes in elevation of less than 12 inches exist in the means of egress, sloped surfaces are used (PBCC Section 1003.5). Throughout a Group I-2 Occupancy, any change in elevation in portions of the means of egress that serve nonambulatory persons are by means of a ramp or sloped walkway (PBCC Section 1003.5). The exit access to the southwest stairway and the horizontal exit to the adjoining hospital includes a ramp meeting these requirements.

Elevators are not used as a component of a required means of egress from any part of the building (PBCC Section 1003.7).

27. Total Building Movement Time

The total occupant load for each entire floor is given in Appendix K. These occupant loads will be used in an analysis to determine the total evacuation time for the MCS building.

The hydraulic calculation procedure outlined on page 3-385 of the SFPE Handbook will be used for this analysis. After calculating the occupant load for each space in the building, the characteristics of the limiting features of egress must be determined. A summary of the effective width, specific flow, and flow rate of each pertinent building component is given in Table 10.

Table 10. Summary of building egress components

Component	Effective Width, ft.	Specific Flow, p/ft*min	Flow Rate, p/min	Velocity, ft/min	Number of Components
Concourse Floor (541 occupants)					
Typical Corridor leading to Stairway or Horizontal Exit	5.08	24.0	121.9	137.4	N/A
Door through Horizontal Exit	2.50	24.0	60.0	137.4	1
Door into Southwest and Northeast Stairways	2.00	24.0	48.0	137.4	1 each
Southwest/Northeast Stairway	2.67	18.5	49.4	105.9	N/A
Stairway Discharge Door	2.00	24.0	48.0	137.4	1 each
First Floor (572 occupants)					
Typical Corridor leading to Stairway or Horizontal Exit	5.08	24.0	121.9	137.4	N/A
Door through Horizontal Exit	2.50	24.0	60.0	137.4	1
Door into Southwest and Northeast Stairways	2.00	24.0	48.0	137.4	1 each
Southwest/Northeast Stairway	2.67	18.5	49.4	105.9	N/A
Stairway Discharge Door	2.00	24.0	48.0	137.4	1 each
Main Building Exit	8.0 (for 4 doors)	24.0 (for a door)	192.0 (total)	137.4	4 doors total
Second Floor (513 occupants)					
Typical Corridor leading to Stairway or Horizontal Exit	5.08	24.0	121.9	137.4	N/A
Door through Horizontal Exit	2.50	24.0	60.0	137.4	1
Door into Southwest and Northeast Stairways	2.00	24.0	48.0	137.4	1 each
Southwest/Northeast Stairway	2.67	18.5	49.4	105.9	N/A
Stairway Discharge Door	2.00	24.0	48.0	137.4	1 each
Third Floor (528 occupants)					
Typical Corridor leading to Stairway or Horizontal Exit	5.08	24.0	121.9	137.4	N/A
Door through Horizontal Exit	2.50	24.0	60.0	137.4	1
Door into Southwest and Northeast Stairways	2.00	24.0	48.0	137.4	1 each
Southwest/Northeast Stairway	2.67	18.5	49.4	105.9	N/A
Stairway Discharge Door	2.00	24.0	48.0	137.4	1 each

The effective width of a component is equal to its nominal width minus twice the boundary layer width given in Table 3.13.1 in the SFPE Handbook. The boundary layer width given for stairwells is 6 inches, the boundary layer for a corridor is 8 inches, and the boundary layer for a door is 6 inches.

The typical corridor on the concourse level is 6 feet 5 inches wide, so the effective width is 61 inches, or 5.08 feet. The typical door through a horizontal exit is 3 feet 6 inches wide, so the effective width is 30 inches, or 2.5 feet. The doors into the northeast and southwest stairways are 3 feet wide, so the effective width is 24 inches, or 2 feet. The stairway discharge doors are 3 feet wide, giving an effective width of 24 inches, or 2 feet. The stairways themselves are 44 inches wide, giving an effective width of 32 inches, or 2.67 feet.

The specific flow of a component is calculated as:

$$F_s = D * v$$

Where F_s is specific flow, D is the density of the flow, and v is the velocity of the flow. The starting density of people on the floor will be assumed as the value that produces the maximum possible specific flow, 0.175 p/ft^2. This was taken from page 3-380 of the SFPE Handbook, which recommends that this density be used for engineering designs.
The velocity of the flow is calculated as:

$$v = k - 2.86 * k * D$$

Where k is the proportionality constant for egress components (SFPE Handbook, Table 3.13.2) and D is the density of the flow. For 7-11 stair treads, k is 212 ft/min. For a door, corridor, or walkway, k is 275 ft/min.

The flowrate is calculated as:

$$flow\ rate = F_s * effective\ width$$

Using these three equations above, the values in Table 10 were calculated.

27.1. Movement Time Calculation Procedure

Each floor of the MCS Building is divided into two smoke compartments by a horizontal exit. The MCS Building does not account for the horizontal exits during evacuation; instead, only the fire floor is evacuated. If necessary, the entire building may be evacuated sequentially. To obtain an estimate of how long it would take to evacuate the entire building, the analysis in this section will focus on total evacuation. Occupants must use the stairways, horizontal exit to the hospital, or the main building exit to totally evacuate the building.

The flowrate in the typical corridor is 121.9 p/min, the flowrate through the typical horizontal exit door is 60.0 p/min, the flowrate through stairwells is 49.4 p/min, and the flowrate through stairway entrance/discharge doors is 48 p/min. Corridors are not the limiting egress feature, because they have a much higher flowrate than the horizontal exits or the stairways. For stairways, the limiting egress component is the stairway entrance/discharge door, which has a lower flowrate than the stairway itself.

Because the flowrate descending the stairway is greater than the flowrate through the door, a queue forms at the stairway door. Also, because the flowrate is limited by the stairway door, the flowrate through the stairway entrance door, down the stairway, and out the discharge door is limited to 48.0 p/min. Therefore, the specific flow is:

$$\frac{48.0\ \frac{p}{min}}{2.00\ ft.effective\ width} = 24.0\ \frac{p}{min * ft}$$

The floor-to-floor vertical distance is 12 feet. Using a conversion factor of 1.85 (SFPE Handbook, Table 3.13.3), this translates to an equivalent horizontal travel distance of 22.2 feet. Between each floor is 32 feet of landing that must also be traveled. At a velocity down the stairway of 105.9 feet/min, it will take 0.51 minutes total to travel between floors in a stairway:

$$\frac{54.2\ feet\ of\ travel\ total}{105.9\ feet/min} = 0.51\ minutes$$

Assuming all occupants begin evacuating at the same instant, the first people from the second floor and concourse floor will reach the stairway discharge doors on the first floor after approximately 0.51 minutes. At this time, a queue will form at the discharge door, because the occupants from both the second floor and concourse floor are trying to use the first floor discharge door, which has a flowrate less than the sum of the flowrate from the floors above and below. Therefore, egress will be limited by the exit discharge door for the stairways.

A queue will also form at the west horizontal exit door, because the corridor flowrate is higher than the flowrate through the horizontal exit door.

A queue could potentially form at the main building exit, because 5 individual corridors lead to the building exit. In the worst case, if each corridor was at its maximum flowrate, 610 p/min would be going towards this exit, and its maximum flowrate is only 228 p/min.

In order to calculate the minimum required egress time, it will be assumed that occupants use each exit in the optimum balance. This means that the queue that forms at every exit dissipates at the same time, so that no one exit takes longer to evacuate people than any other exit. This will optimize egress time.

After the queue forms at each of the two exit stairways, which occurs at 0.51 minutes, they will evacuate people at a rate of 48 p/min each, limited by the first floor stairway exit doors. After the queue forms at the west horizontal exit to the hospital building, which occurs at 0.51 minutes, it will evacuate people at a rate of 60 p/min on each floor. It is assumed that the queue forms at the west horizontal exit at the same time as the stairway. This is conservative, because faster travel distances on horizontal surfaces will result in the first occupants reaching the horizontal exit in a shorter time than it would take to travel between floors in a stairway.

After the queue forms at the main building exit, it will evacuate people at a rate of 228 p/min. This exit will not be responsible for evacuating people on floors other than the first floor, because people are not expected to egress from a different floor through a stairway, leave the stairway on the first floor, and then proceed to the main building exit. This is a conservative assumption, because using the main building exit in this manner in this analysis would result in an unrealistically low minimum evacuation time.

27.2. Hand Calculation

The concourse floor has an occupant load of 541 occupants, the first floor has 572 occupants, the second floor has 513 occupants, and the third floor has 528 occupants. If the exits are used in the optimum balance, the egress time through each exit with its allocated occupant load will be the same for every floor. So for the first floor:

$$\frac{Horizontal\ exit\ occ.}{60\ p/min} = \frac{Northeast\ stairway\ occ.}{48\ p/min} = \frac{Southwest\ stairway\ occ.}{48\ p/min} = \frac{Main\ exit\ occ.}{192\ p/min}$$

$$Horizontal\ exit\ occ. + Northeast\ stairway\ occ. + Southwest\ stairway\ occ. + Main\ exit\ occ. = 572$$

Solving the equations above yields about 1.6 minutes for each egress component to evacuate its occupant load, if occupants are distributed among the egress components optimally.

After the first floor proceeds through the stairway exit doors on the first floor (1.6 minutes), occupants from the second and concourse floors who are queueing in the stairways can begin using them. For simplicity, it will be assumed that the entire occupant load from one floor must completely evacuate before the stairwells will evacuate anyone else from another floor. Although it is true that occupants from the second floor and concourse floor will likely reach the stairwell exits at the same time and begin evacuating in something resembling an alternating manner, the effective time to evacuation would be the same as if one entire floor evacuated before another.

For the concourse floor:

$$\frac{Horizontal\ exit\ occ.}{60\ p/min} = \frac{Northeast\ stairway\ occ.}{48\ p/min} = \frac{Southwest\ stairway\ occ.}{48\ p/min}$$

$$Horizontal\ exit\ occ. + Northeast\ stairway\ occ. + Southwest\ stairway\ occ. = 541$$

Solving the equations above yields about 3.5 minutes for each egress component to evacuate its allocated occupant load, if occupants are distributed among the egress components optimally.

For the second floor:

$$\frac{Horizontal\ exit\ occ.}{60\ p/min} = \frac{Northeast\ stairway\ occ.}{48\ p/min} = \frac{Southwest\ stairway\ occ.}{48\ p/min}$$

$$Horizontal\ exit\ occ. + Northeast\ stairway\ occ. + Southwest\ stairway\ occ. = 513$$

Solving the equations above yields about 3.3 minutes for each egress component to evacuate its allocated occupant load, if occupants are distributed among the egress components optimally.

For the third floor:

$$\frac{Horizontal\ exit\ occ.}{60\ p/min} = \frac{Northeast\ stairway\ occ.}{48\ p/min} = \frac{Southwest\ stairway\ occ.}{48\ p/min}$$

$$Horizontal\ exit\ occ. + Northeast\ stairway\ occ. + Southwest\ stairway\ occ. = 528$$

Solving the equations above yields 163 occupants to each stairway, and 202 occupants to the horizontal exit. It will take about 3.4 minutes for each egress component to evacuate its allocated occupant load.

In summary, it will take 0.5 minutes for the queues to form, and 1.6 minutes for the first floor to be evacuated and for the occupants from the second and concourse floors to use the stairway discharges. It takes 3.5 minutes to evacuate the concourse floor, 3.3 minutes to evacuate the second floor, and 3.4 minutes to evacuate the third floor.

$$0.5 + 1.6 + 3.5 + 3.3 + 3.4 = 12.3\ minutes$$

The calculated movement time for all occupants to completely evacuate the building is 12.3 minutes.

It should be noted that several optimizing assumptions are inherent in this calculation, so this is the minimum possible evacuation time for the building. It is highly likely that the actual movement time would take longer than this. This calculation does not take into account the effect of a stairway or other exit being compromised during an evacuation, which could significantly increase the needed movement time. Also, it is virtually certain that occupants will not use the exits in an optimum balance as was calculated, which would also increase the needed movement time. This calculation simply gives an estimate of the minimum time needed to fully evacuate the entire building, if each exit is operational and the exits are used optimally.

27.3. Pathfinder Simulation Comparison with Hand Calculations

An evacuation simulation was built using the Pathfinder program to verify the hand calculated total building movement time. Figure 23 below is a screenshot from the Pathfinder model that was used. The widths of all exit components in the Pathfinder model match those found in the actual building. The actual occupant load of each floor was also reproduced in the Pathfinder model.

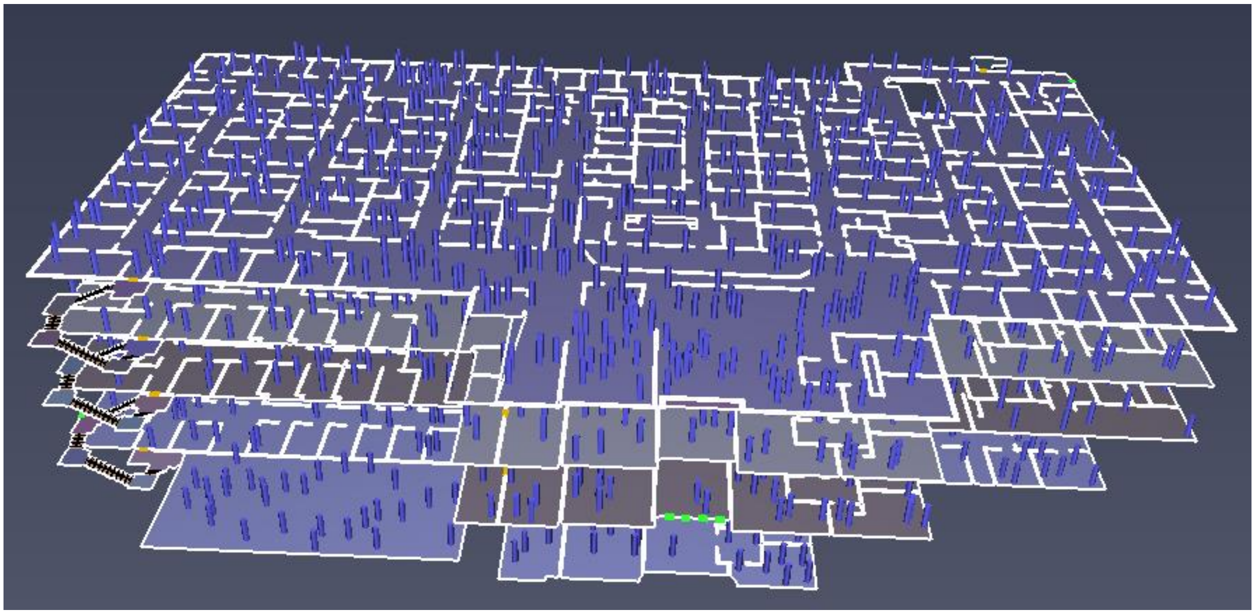

Figure 23. Pathfinder total building evacuation model screenshot

As shown by Table 11 below, the evacuation times modeled in Pathfinder using both the SFPE and Steering calculation methods agree well with the time calculated by hand.

Table 11. Total building evacuation movement times

Calculation Method	Total Building Evacuation Movement Time
Pathfinder (SFPE calculation method)	13.0 minutes
Pathfinder (Steering calculation method)	10.5 minutes
Hand calculation result	12.3 minutes

28. Pre-Movement Time

Besides the movement time calculated above, the pre-movement time is another vital component of total evacuation time. Pre-movement time for various buildings depends on the type of occupancy of the building. For example, apartment buildings tend to have longer pre-movement times than office buildings, most likely because people spend time gathering important belongings or rounding up children and pets before evacuating. In an office building, people spend less pre-movement time because there aren't many important belongings to secure except perhaps a computer or cell phone.

Occupant characteristics that are generally considered when evaluating an appropriate pre-movement time (and movement time) include:

- **Alertness**: For the MCS Building, it can be expected that occupants are awake and alert, since most of them are doctors or nurses whose offices are in the building. The Group I-2 Occupancy area on the concourse floor, where a few patients may not be entirely alert, is small compared with the area of the rest of the building. Also, technicians or doctors will be with these patients, so in the event of a fire, they could easily alert the patient.

- **Responsiveness**: The occupants of the building will be of average responsiveness, with an unimpaired ability to sense cues and react. Since the building is primarily an office building, most occupants on a given day will be alert and responsive, since they are working at their job.

- **Commitment**: The occupants will be working at their job, but will be able to abandon whatever task they are working on in the event of a fire alarm. Their jobs will not require the full commitment of a surgeon since in-patient surgery does not take place in the building.

- **Focal point**: This is not a factor with much impact for this building, since there is no performance or assembly function going on. Occupants are focused on their work, which they will be able to abandon easily and quickly in the event of a fire.

- **Physical/mental capabilities**: For the reasons previously discussed, the small Group I-2 Occupancy area will not have much effect on the pre-movement time of the rest of the building. It can be assumed that the occupants generally have the physical/mental capability to work at their job effectively, and so do not have any disability that will affect their ability to escape. It is possible there may be some occupants with mobility, sight, or hearing disability, but this should not greatly impact pre-movement time since they will be accompanied by doctors or nurses.

- **Familiarity**: The doctors and nurses whose offices are in the building are extremely familiar with their surroundings. Visiting patients may not be but will have the staff to guide them.

- **Role**: The visiting patients who may not be familiar with the building can follow the egress of the doctors and nurses who are familiar with the building in case of a fire.

- **Social affiliation**: There are no children or pets for the doctors and nurses to gather before exiting the building, so the majority of occupants will act as individuals in a fire event.

For the MCS Building, pre-movement time will be evaluated considering that the building is primarily a Group B Occupancy and consists mostly of offices. The consideration of occupant characteristics above shows that the majority of occupants will have the same characteristics as people working in an office building. Therefore, it can be expected that pre-movement time will be similar to that of an office building.

Delay times derived from drills and actual fire scenarios are listed in Table 3.12.2 of the SFPE Handbook. Data are listed for mid-rise office buildings, which were collected by Proulx, Kaufman, and Pineau in a study on pre-movement times (SFPE Handbook, page 3-371). For a mid-rise office building, which resembles the MCS Building, the pre-movement times range from 0 minutes to 5 minutes, with a mean between 0.6 minutes and 1.1 minutes (SFPE Handbook, Table 3.12.2). A value of 5 minutes will be used as an estimate of the pre-movement time of the MCS Building, since it is likely that the characteristics of the occupants resemble those of the other mid-rise office buildings studied.

29. Total Building Evacuation Time

Adding together the movement time and the pre-movement time gives a total minimum evacuation time for the MCS Building of **17.3 minutes**. This is the minimum possible evacuation time for the entire building, assuming the entire building is evacuated at once, with all exits available, and occupants optimally distribute themselves among the available exits.

This total building evacuation time will not be used as a RSET criterion. This is because normally the MCS Building uses a staged evacuation plan, where only the fire floor is evacuated. This causes both RSET and ASET times for certain design scenarios to differ from one another, depending on which floor a fire occurs. Also, the possibility of exits being compromised by the location of a fire could result in significantly longer evacuation times. The detection time for the fire would also differ between scenarios, and would need to be added to the evacuation time to arrive at a RSET criterion. This process will be discussed further in the performance-based analysis section of this report, where several design fire scenarios will be considered.

30. Egress System Summary

The MCS Building egress system is in compliance with all applicable requirements of the PBCC and PFC. Occupant loads should be maintained below the maximum allowable for each space, exit access corridors should be kept free of obstructions, and doors should be easily accessible and also free of obstructions. Maintaining the integrity of the egress system in this way will allow each component to perform its intended function, and set the stage for a successful evacuation in case of fire.

The prescriptive portion of this report has considered the design of the structural fire protection, suppression, detection and alarm systems, in addition to the egress system. The next section of this report will consider how these separate fire protection features would work together in a performance-based analysis.

31. Performance-Based Analysis Concept

A performance-based analysis involving fire scenarios in several different locations in the MCS Building was conducted. The goal of the performance-based analysis was to examine several likely design fire scenarios and determine whether or not the fire protection systems in the building provide occupants with enough time to escape the effects of the fire. The first step in this process was to determine tenability criteria for the scenarios, or the conditions which occupants can be exposed to without succumbing to the effects of the fire.

32. Tenability Criteria

The 2015 Life Safety Code (LSC) contains provisions for establishing criteria for performance-based design. The main goal of establishing these criteria is to ensure that any occupant who is not intimate with ignition will not be exposed to instantaneous or cumulative untenable conditions (LSC Section 5.2.2). There are four methods outlined in the LSC to realize this goal, and in order to perform a tenability analysis on the MCS Building, Method 1 was used.

Method 1 allows that occupants are exposed to some fire effects, but involves setting detailed performance criteria to prevent incapacitation of occupants from those fire effects. The main fire products that have the capability to directly or indirectly incapacitate occupants are the combined toxic effects of asphyxiant gases and irritant gases, the effects of smoke on visibility, and thermal effects including direct hot gas exposure and exposure to radiation from fire.

32.1. Toxicity

Asphyxiant gases, particularly CO_2, HCN, and CO, incapacitate occupants by reducing their access to oxygen. CO_2 displaces oxygen, and is capable of incapacitating occupants in high enough concentrations. CO interacts with hemoglobin in the blood to chemically reduce the body's access to oxygen, and affects occupants quickly even in low concentrations. Another side effect of CO_2 is that it induces hyper-ventilation, which increases the uptake of asphyxiant gases such as CO and HCN. As a fire produces CO_2 and CO, it will simultaneously induce hyper-ventilation and reduce access to oxygen, which can quickly incapacitate occupants.

Irritant gases, while not as toxically potent as CO and HCN, can contribute to incapacitation. At increasingly high concentrations, irritant gases can cause acute pulmonary irritant response, and extreme pain to the eyes and lungs, which makes egress extremely difficult. Irritant gases themselves must be present in exceptionally high concentration to cause incapacitation themselves, but they certainly contribute to the likelihood of delayed egress, and therefore a higher likelihood of incapacitation from other effects.

The effects of asphyxiant gases and irritant gases, combined with oxygen deprivation, are accounted for with the FED model, presented by Purser in the SFPE Handbook. The model is as follows:

$$F_{IN} = \left((F_{ICO} + F_{ICN} + FIC) * V_{CO2} + F_{IO}\right)$$

where F_{ICO} is the FED of CO, F_{ICN} is the FED of hydrogen cyanide (HCN), FIC is the fraction of an irritant dose contributing to hypoxia, V_{CO2} is the multiplication factor for CO_2 induced hyper-ventilation, F_{IO} is the FED of low-oxygen hypoxia, and F_{IN} is the FED of all asphyxiant gases. Although the yields and concentrations of each of these gases in the smoke produced could be used with this model to produce a fractional effective dose value, it would be a highly complex calculation and provides an unnecessary level of detail. Instead, there is a simplified method that will be used for this performance-based analysis.

As stated in the SFPE Handbook, "there is little doubt that carbon monoxide is the most important asphyxiant agent formed in fires…it is the major ultimate cause of death in fires" (SFPE Handbook, p.2346). Since carbon monoxide is a critical component of the toxicity of fire gases, it will be the focus of the toxicity tenability criteria for the MCS Building. Although the FED model does include the effects of irritant acid gases, data on the yields of these products from the fuels used in the design fire are not readily available. The SFPE Handbook also acknowledges the difficulties in obtaining this data: "in practice, the relevant yield data for the key irritant species are seldom available, and not all the important species have been identified" (SFPE Handbook, p.2319). If halogen, sulfur, and nitrogen content in the burning fuel is low, the contribution to the FED from irritant acid gases is minor (SFPE Handbook, p.2319). Although there is some nylon content in the design fire, the percentage is relatively low. There is little halogen or sulfur content in the burning fuel. For these reasons, carbon monoxide will be the focus of the tenability criteria, and the contribution from irritant acid gases will be neglected.

Table 63.9 of the SFPE Handbook gives exposure doses of carbon monoxide for various subjects and levels of activity (SFPE Handbook, p.2351). For a human engaged in light activity (such as egress), the lower bound for a carbon monoxide dose expected to cause incapacitation is 30,000 ppm*min. From the computer evacuation models, it was found that any floor evacuation is unlikely to take longer than 20 minutes. Dividing 30,000 ppm*min by 20 minutes gives a carbon monoxide concentration of about 1500 ppm. This would be the dose of carbon monoxide expected to cause incapacitation in a human engaged in light work for 20 minutes. It will be investigated whether occupants in the MCS Building would be exposed to carbon monoxide concentrations exceeding 1500 ppm during a design fire.

32.2. Visibility and Smoke Obscuration

Smoke, like irritant gases, does not directly cause incapacitation, but makes egress very difficult due to visibility issues. Exit choice, escape decisions, wayfinding ability and the speed of movement are all affected by decreased visibility due to smoke. If occupants are delayed in finding their way out of the building, they will be exposed to asphyxiant gases longer, which increases the chances of incapacitation.

Reduced visibility due to smoke will have a larger impact on occupants unfamiliar with an egress route than it will on occupants familiar with the egress route. The SFPE Handbook suggests that a 10 meter (33 ft) visibility criteria is generally accepted (SFPE Handbook, p. 2-132), and the Smoke Control Engineering Handbook suggests that a 25 ft. to 30 ft. visibility criteria can be used for occupants familiar with an escape route (SCHE, p. 186). Almost all occupants in the MCS Building will be familiar with the escape route since their office is in the building, so a conservative visibility criterion of 35 feet will be used for the tenability analysis. The Pathfinder and FDS simulations of the design fires will be used to ensure that visibility is maintained on an egress flow basis, so that evacuating occupants are not exposed to visibility levels below 35 feet during the evacuation process.

32.3. Thermal Effects

Thermal effects can cause incapacitation via heat stroke, body surface burns, and respiratory tract burns. At temperatures above about 120°C (SFPE Handbook, page 2-140), victims are likely to suffer burns and die during or immediately after exposure, due principally to hyperthermia. Burns of the upper respiratory tract and secondary effects of skin burns can also be lethal, even if the victim endures the hyperthermia phase. Both radiant heat and convective heat can contribute to incapacitation due to thermal effects.

Although it is possible to calculate the exposure to radiant heat effects and convective heat effects and form an FED model for thermal effects, a simplified approach to thermal effects tenability is used for this performance-based analysis. If direct contact with a body of gas is an acceptable heat exposure, then thermal radiation exposure some distance away is also acceptable (SCEH, p. 186). Using this logic, a single upper limit for gas temperature can be used as a thermal tenability criterion without the added complexity of calculating radiant heat exposure.

From Figure 2-6.27 from the SFPE Handbook, exposure to about 120°F water-saturated air is tolerable for about 25 minutes. Exposure to about 150°F dry air is also tolerable for about 25 minutes. Since the Pathfinder models indicate evacuation times of less than 25 minutes for each case (discussed in the Computer Modeling Results section of this report), a conservative gas temperature criterion of 120°F is used for thermal effects tenability analysis. Using the Pathfinder and FDS simulation overlays, it will be investigated whether or not occupants are exposed to gas temperatures above 120°F on an egress flow basis.

33. Design Fire

The design fire chosen for the MCS Building was based on a hazard analysis considering the various types of spaces in the building and the types of commodities likely to be present in those spaces. The fire protection systems in place in those spaces were also considered, as well as the location of the spaces in the building relative to evacuation routes.

33.1. Design Fire Location

There are several miscellaneous lab storage rooms scattered throughout the building. These rooms are generally very small in relation to other spaces in the building. They are provided with sprinkler protection, as well as smoke detection. The lab storage rooms are likely to contain small quantities of compressed oxygen, and small quantities of combustible and flammable liquids. This presents a fuel load that could result in a fast growing, relatively challenging fire. However, because the lab storage spaces are generally very small, there isn’t a large quantity of combustibles present, and therefore not a very large fuel load. Also, the presence of both quick-response sprinkler protection and smoke detection in these spaces means that a fire in one of these rooms will likely be promptly detected and suppressed before it becomes uncontrollable. The lab storage rooms are typically located near the edges of the floors of the building or near the middle of the floor, and are typically far from egress components such as the stairwells and horizontal exits.

Machinery rooms and electrical rooms in the MCS Building also present a possible design fire scenario. The large mechanical, plumbing, and electrical rooms are located on the concourse level and are fairly large spaces compared to other spaces in the building. They contain high-powered electrical equipment and hot machinery that pose a greater ignition hazard than what is found elsewhere in the building. However, even though there is a greater ignition risk and a larger space, these machinery and electrical rooms do not contain large quantities of combustibles. They contain only the equipment that they are meant to house, and there is no storage of any other combustibles. Therefore, there is a less dense fuel load present in the machinery and electrical rooms compared to other spaces. In addition, the machinery and electrical rooms are provided with both quick-response sprinkler protection and smoke detection, which means an incipient fire in one of these spaces is very likely to be promptly detected and suppressed. The large machinery and electrical rooms are present only on the concourse floor of the building, in the southeast corner, very far from the stairwells and the horizontal exit to the hospital.

There are many medical offices located throughout the MCS Building, on every floor. These offices can be much larger than the lab storage rooms, but they are smaller than the concourse level machinery and electrical rooms. The offices don't contain obvious high-flammability fuel loads like the lab storage rooms, but are larger and therefore contain a larger fuel load. This fuel load consists mainly of desks, chairs, paper products, limited quantities of plastics, and possibly small electronic appliances. The electronic appliances found in the offices may present a lower ignition risk than the machinery and electrical rooms, but the offices have a much more dense fuel load. Also, it is important to note that while the offices have sprinkler protection like the lab storage rooms and machinery/electrical rooms, the offices are not equipped with smoke detection. This means that an incipient fire in an office is going to provide a later warning to occupants, because sprinklers will not detect a fire as fast as a smoke detector. Finally, it is also important to note that the spaces closest to the stairwells and horizontal exits used for egress are almost always offices. A fire located in one of these offices, if allowed to grow large enough, can begin to block access to these egress components, which would be a serious issue during evacuation.

The medical offices in the MCS Building were chosen as the location for the performance-based analysis design fires, because they typically represent a reasonably large, dense fuel load, they do not have the benefit of smoke detection, and they are the spaces closest to the main egress components.

The particular offices used for the design fires will be those in close proximity to the main egress components, as well as among the larger offices present in the building. This is because the larger offices will likely have slower sprinkler response times: since they are classified as Light Hazard, the sprinkler spacing is 15 ft. by 15 ft. Offices smaller than this will have the benefit of smaller sprinkler coverage areas, while offices larger than this will be subject to the maximum sprinkler coverage area.

33.2. Design Fire Burning Characteristics

As previously discussed, the offices selected as the location for the design fires will contain a fuel load consisting primarily of desks, chairs, tables, paper products, limited quantities of plastics, and small electronics such as computers, printers, and fax machines. The selection of the design fire heat release rate reflects this fuel load composition.

Following the events of 9/11, NIST performed testing investigating the performance of office workstations in fires. The tested workstations were arrangements of desks, chairs, cubicle walls, bulletin boards, computers and computer monitors, stacks of paper, and assorted office supplies. This should closely resemble the typical medical office set-up found in the MCS Building. NIST recorded the individual components in the fuel load, and the combustible mass of those components. These records are shown in Table 12 below. Table 13 shows the fraction of the total mass of the fuel load made up of each type of component, either wood/laminate, paper, plastics, or carpet.

Table 12. Contents of workstations used in NIST 9/11 fire tests

Component	Mass (kg)	Combustible Fraction	Combustible Mass (kg)
Work surface – melamine laminate over medium density fiber-board 4 pieces, 6.1 m total length × 0.61 m wide × 28 mm thick	82.8	1.0	82.8
27 reams of paper and 14 document boxes	63.7	1.0	63.7
Plastic kick plates and trim (base of walls, inside and outside)	7.1	1.0	7.1
Computer keyboard	1.2	1.0	1.2
Plastic waste basket	0.7	1.0	0.7
36 nylon carpet tiles with rubber backing	38.0	0.9	34.2
Shelf ends – particle board or dense foam	3.8	0.9	3.4[a]
Bulldog chair – fabric, foam, thermoplastic shell and base	19.4	0.8	15.5
Computer monitor - ABS	17.6	0.3	5.3
Computer processor	12.3	0.3	3.7
9 wall panels with aluminum angle, wood frames, fiberglass, and metal mesh, 3 sizes	168.2	0.18	30.3 25.3 kg wood 5.0 kg fabric
Book shelf	8.3	0.1	0.8
3 two-drawer steel filing cabinets, 0.91 m long × 0.51 m deep × 0.76 m high	142.5	0.0	0.0
Total	**557.1**	**0.45**	**248.7**

Table 13. Fractions of the total fuel load mass categorized by material type

Material	Mass (kg)	Fraction of Total Mass	Effective Heat of Combustion (MJ/kg)
Wood/laminate	111.5	0.45	14
Paper	63.7	0.25	14
Plastics[a]	39.3	0.16	16 to 38
Carpet	34.2	0.14	22

a. Includes computer monitor shell (16 MJ/kg), wall fabric (30 MJ/kg), and chair composite (38 MJ/kg).

This information on the relative fractions of material found in this fuel load was used to develop the product yields of the design fire used in the MCS Building performance-based analysis. The product yields will be weighted 70% towards those of cellulosics (approximated as red oak), 16% towards those of plastics (approximated as polystyrene, typically used in plastic computer shells), and 14% towards those of carpet (assumed to be nylon fibers). The product yields of the design fire are shown below in Table 14. Product yield information was taken from the SFPE Handbook, 4th edition, Table 3-4.16. The chemistry model of the fuel was determined using the same weighting process. Chemical formula information was taken from the SFPE Handbook, 4th edition, Table 3-4.15. Table 15 indicates the values used for the chemistry model of the design fires.

Table 14. Product yields of MCS Building design fires

Component	Fraction of Total Mass	Soot Yield	Carbon Monoxide Yield
Cellulosics (red oak)	70%	0.015	0.004
Plastics (polystyrene)	16%	0.164	0.060
Carpet (nylon)	14%	0.075	0.038
Design Fire	100%	0.047	0.018

Table 15. Chemistry model of MCS Building design fires

Component	Fraction of Total Mass	Carbon	Hydrogen	Oxygen	Nitrogen
Cellulosics (red oak)	70%	1	1.7	0.72	0.001
Plastics (polystyrene)	16%	1	1	0	0
Carpet (nylon)	14%	1	1.8	0.17	0.17
Design Fire	100%	1	1.6	0.53	0.025

Besides the product yields and chemistry model, the heat release rate of the design fire was also determined using NIST data from the tested workstations. The workstations were first ignited using jet fuel to resemble the 9/11 scenario, but jet fuel is not likely to be an ignition source for an office fire in the MCS Building. Following the ignition, the fires resulting from the NIST workstation tests tended to grow to a peak HRR of about 7.5 MW (including the 2

MW jet fuel igniter) at about 600 seconds following ignition, following a "t-squared" growth pattern. The fire then went through a decay stage, decreasing heat release rate approximately linearly, until the jet fuel burner was shut off at about 2400 seconds. The heat release rate data taken from one of these NIST workstation tests is shown below, in Figure 24.

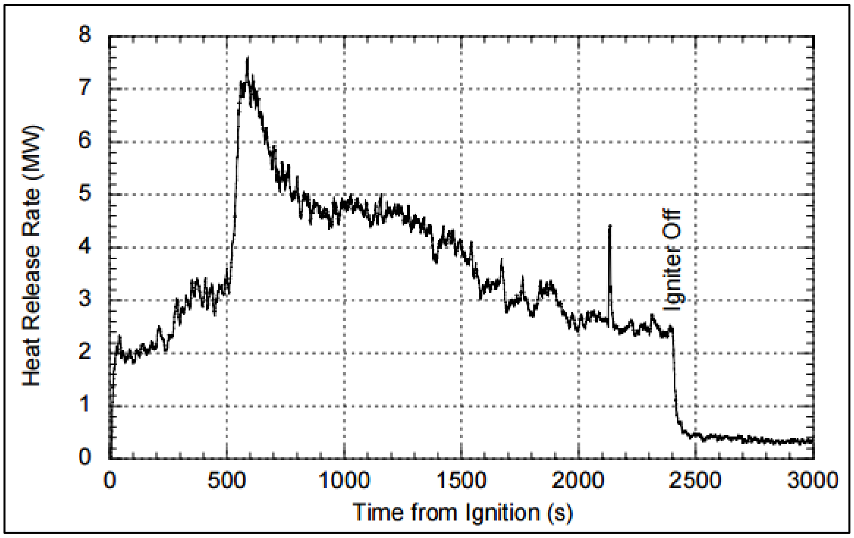

Figure 24. Heat release rate data from a typical 9/11 NIST workstation fire test

Further details about these workstation tests, including the total mass loss, net heat released, effective heat of combustion, and other information, is reproduced below in Table 16.

Table 16. Measured quantities and details of NIST workstation fire tests

Quantity	Test						Uncertainty
	1	2	3	4	5	6	
Workstation	½ Generic	Generic	Generic	WTC	Generic	Generic	
Tiles	N	N	Y	N	N	Y	
Jet fuel	N	N	N	N	Y	Y	
Peak HRR[a] (MW)	5.92/5.77	8.70/8.48	7.56/7.30	9.89/9.66	9.12/8.91	7.960/7.60	14.6 %/13.2 %
Time to peak[g] (s)	490	530	590	510	160	200	4.4 %/7.2 %
Net peak HRR[a] (MW)	3.82/3.67	6.95/6.73	5.53/5.27	7.72/7.46	7.38/7.17	6.17/5.95	15.0 %/13.6 %
Peak MLR (kg/s)	0.197	0.308	0.263	0.420	0.336	0.293	12.8 %
Time to peak[g] (s)	480	530	560	490	160	180	4.4 %/7.2 %
Net heat released (GJ)	1.20	4.05	4.13	2.93	3.60	3.74	14.9 %
Time interval[b] (s)	150 to 1265	50 to 3200	160 to 3600	30 to 2100	0 to 2500	20 to 2520	
Total mass loss (kg)	69.1	205.0	213.6	173.6	200.2	205.3	4.4 %
Effective heat of combustion (MJ/kg)	17.4	19.8	19.3	16.9[c]	18.0	18.2	15.0 %
FWHH[d] (s)		244	445		318	451	11.6 %, 43.6 %,10.8 %,12.8 %
t(75 %)[e]		1311	1453		833	1009	4.6 %, 5.5 %
t_{ig}[f] (s) (item ignited)	39 (paper)	67 (paper)	56 (paper)	50 (paper)	90 (Jet A)	114 (paper)	62 %, 36 % 43 %, 48 %, 27 %, 21 %

a. The first HRR number is the calorimeter output; the second is a 10 s average about the absolute peak; the first uncertainty number is for the instantaneous peak and the second is the 10 s average about the peak.
b. The time interval applies to both the net heat released and to the total mass loss.
c. There was some spillage of smoke in Test 4, which may partly account for the lower heat of combustion.
d. Full width half height of net HRR curve; the four uncertainty values are for Tests 2, 3, 5, and 6.
e. Time at which 75 percent heat had been released and 75 percent of mass had been lost; the first uncertainty value is for Tests 2 and 3 and the second is for Tests 5 and 6.
f. Time of ignition of first object within workstation; the six values of uncertainties are for Test 1 through Test 6.
g. The first uncertainty number is without Jet A and the second number is with Jet A.

To approximate the typical NIST workstation fire for use in the MCS Building design fire, first the effect of the jet fuel igniter (the added 2 MW) was removed, to produce a maximum HRR of 5.5 MW at 600 seconds. A t-squared fire with a fire growth coefficient of about 0.0153 kW/s^2 was used to produce the heat release rate curve. Since a decay period is shown clearly in the NIST workstation fire tests, a linear decay period was added, with the heat release rate decreasing from a peak of 5.5 MW to 0 MW by 2400 seconds after ignition. This fire growth curve is shown below in Figure 25.

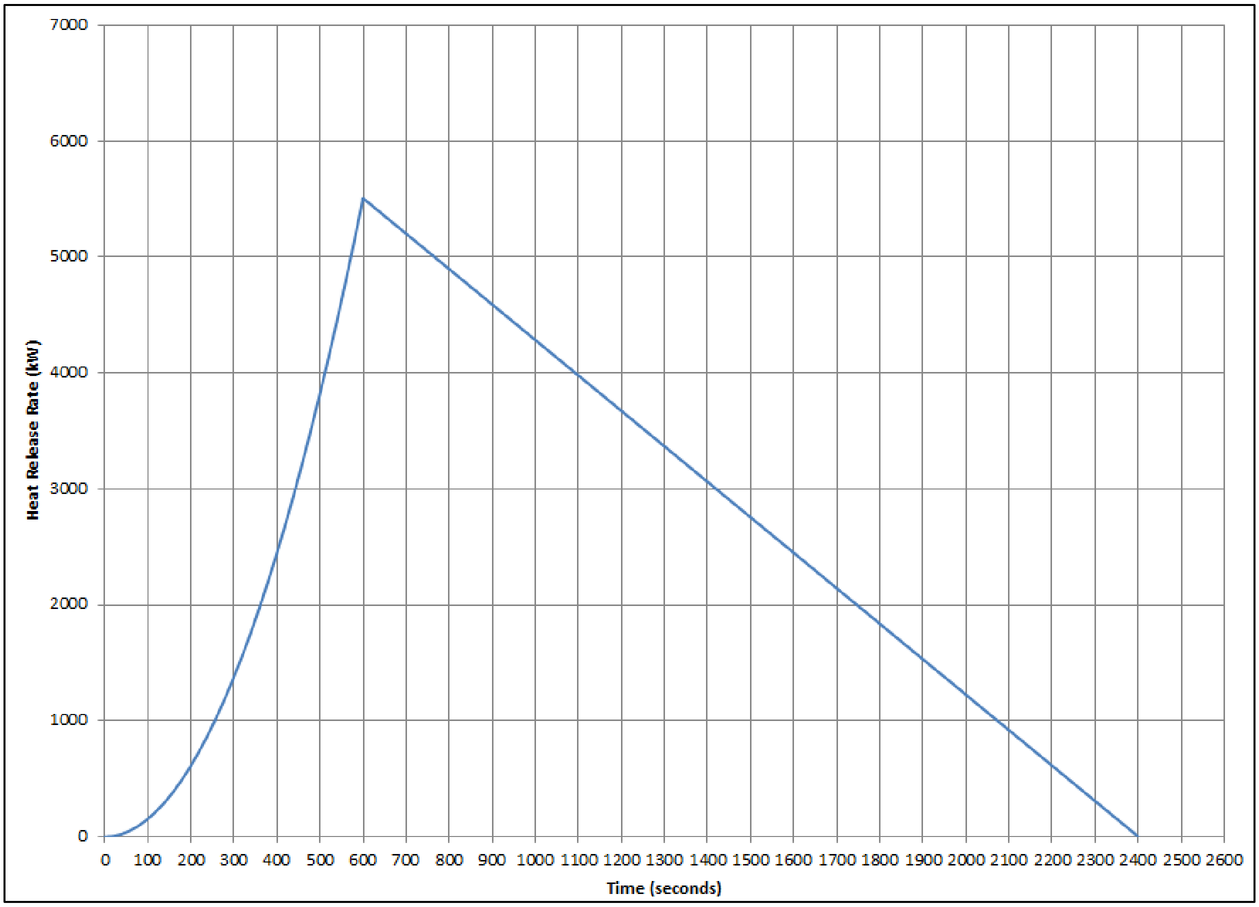

Figure 25. Design fire model utilized based on NIST workstation fire tests

This fire growth curve was used to initially represent the design fire in the scenarios explored. However, once the first sprinklers begin to activate, the heat release rate of the fire is assumed to be held constant as the sprinklers prevent further fire growth. This assumption is discussed further later in this report.

34. Building the Computer Fire and Evacuation Models

In order to model the movement of smoke and fire products through the MCS Building, a model of each floor was created using Pyrosim, which is a graphical user interface (GUI) for the Fire Dynamics Simulator (FDS) program. In addition, each floor of the building was also modeled using Pathfinder, which is an evacuation modeling program produced by Thunderhead Engineering (Pyrosim is also produced by Thunderhead Engineering). As discussed previously in this report, an egress flow approach will be used in the performance-based analysis for the MCS Building. This means that the smoke and fire product movement, over time, will be modeled using Pyrosim/FDS, and compared with the modeled location of evacuating occupants, over time, using Pathfinder. It will be investigated whether or not occupants experience tenable conditions throughout the evacuation process.

Two models were run for the third floor and second floor, one for the west side and one for the east side. For each model, the design fire was placed in an office adjacent to the stairwell, preventing access to the stairwell. The simulated occupants must use the stairway on the other side of the floor to evacuate (or west horizontal exit to the hospital, if available). The first floor was not modeled because the main building exit, two interior exit stairwell doors, and horizontal exit to the hospital caused it to have far lower evacuation times than the other floors, even when access to a stairwell was blocked. Only the west side of the concourse floor was modeled, since the east side has a much smaller occupant load and floor area, making it much easier to evacuate quicker.

The details of the construction of the models are discussed below.

Figure 26 presents an overall visual comparison of the Pyrosim and Pathfinder models to the actual MCS Building.

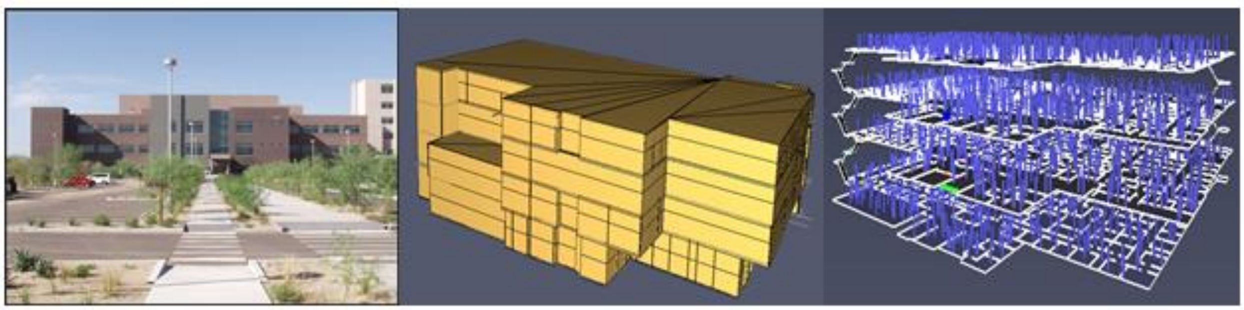

Figure 26. MCS Building, Pyrosim model, Pathfinder model (left to right)

34.1. Pyrosim Modeling

The Pyrosim model of the MCS Building includes all walls and rooms that exist in the real building. For simplicity, no furniture was included in the Pyrosim model. This is justified by the fact that the objective is to model large-scale smoke and fire product movement through the building, and the intricacies introduced by furniture are not necessary. All surfaces are modeled as inert, again, for simplicity and ease of calculation. If the thermal properties of every surface in the building were modeled, the calculation times would greatly increase, and the added level of sophistication would not drastically alter the results of the simulations.

The mesh sizes in the Pyrosim model were all set as cubes with dimensions of 0.125 ft. for individual room simulations, and with dimensions of 1 ft. for large-scale floor simulations. The chemical model of the design fires (discussed previously) was inputted as the reaction, using a composition of 1.0 carbon, 1.6 hydrogen, 0.53 oxygen, and 0.025 nitrogen. A carbon monoxide yield of 0.018 and a soot yield of 0.047 were used. The heat release rate of the burning surface differed depending on the model being run.

Because the model assumes that sprinkler activation controls the heat release rate of the fire and prevents it from growing further, two models were run for each side of each floor. The first model only included the design fire and the room it is situated in, as well as any sprinklers included in the room. The sprinklers are quick-response, and have an activation temperature of 165°F and an RTI of 50 $(m\text{-}s)^{1/2}$. This first model was run for each side of each floor to determine when sprinklers would activate. The second model used the same heat release rate curve as the first, but capped the maximum heat release rate at the value reached by the time of sprinkler activation. The second model included the entire floor area, and included the closest smoke detector to the design fire. The smoke detectors were modeled with the Cleary Photoelectric model. Finally, visibility, temperature, and carbon dioxide gas concentration slice files were included in the large-scale floor models, at 6 ft. above the walking surface.

34.2. Pathfinder Modeling

Like the Pyrosim models, the Pathfinder models of the MCS Building include all walls and rooms that exist in the real building. However, in this model, the floors are joined together by the two interior exit stairwells, so that occupants can use them to travel between floors while evacuating.

Since the stairways are each 44 inches wide, and since they each have a boundary layer of 6 inches (SFPE Handbook, 4th edition, Table 3-13.1), they are modeled in Pathfinder with a width of 32 inches. Doors are all 36 inches wide, and they have a boundary layer of 6 inches (SFPE Handbook, 4th edition, Table 3-13.1), so they are modeled in Pathfinder as 24 inches wide. The main building exit, doors into stairways, doors out of stairways to the public way, doors in the horizontal exit to the adjoining hospital, and floor-dividing horizontal exit doors were all included in the Pathfinder models.

Occupant loads were distributed evenly on each side of the floor-dividing horizontal exit for each simulation, depending on what the calculated occupant load was for that side of the floor (see Table 10). To simulate the loss of a stairwell due to a fire blocking access, the door to the stairway was removed.

Ultimately, to combine the Pathfinder evacuation model results with the Pyrosim fire modeling results, the FDS slice files were overlaid on the Pathfinder models. Then using the color-coding on the slice files, it could be determined the areas in which tenability was and was not violated.

35. Computer Modeling Results

The results of the various design fire scenarios explored with the Pathfinder and Pyrosim models are discussed below.

35.1. Summary of Design Fire Scenarios Explored

The first scenario explored is illustrated below in Figure 27. The design fire is located on the northeast end of the concourse floor, and the fire products are assumed to cut off access to the northeast stairway. Occupants must egress through the southwest stairway or west horizontal exit to the hospital. This scenario was explored both with all doors in the floor-dividing horizontal exit closed, and with one door left open. The reason that the horizontal exit doorway failure mode was examined is because this has been a past mode of failure in the building during fire drills (see Figure 28 below).

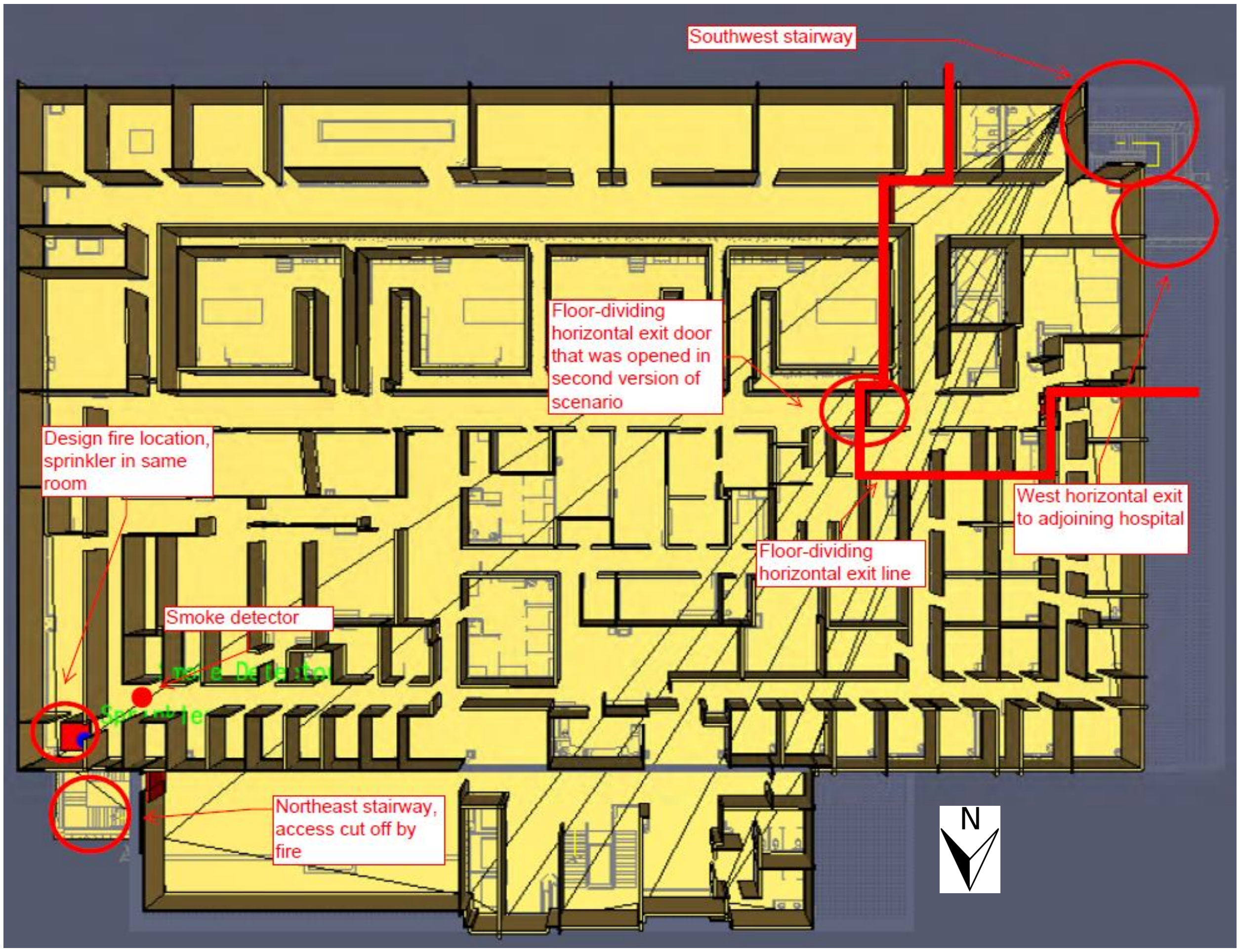

Figure 27. Northeast fire on concourse level

2006 Code Red Drill Summary
Mayo Clinic Hospital

Quarter/Shift	Date	Time	Location	"At Scene" (10/10)	"Away" (6/6)
1/Evening	1/30/06	16:56	2E Short Stay PACU	10/10	6/6 (x3)
1/Day	2/10/06	08:55	3 E – D Pod	10/10	6/6 (x2)
1/Day	2/23/06	11:52	NID	10/10	6/6
1/Evening	3/29/06	17:45	4 West – A Pod	10/10	6/6 (x3)
1/Nights	3/9/06	06:30	5 West	10/10	6/6 (x3)
1/Nights	3/31/06	05:46	2 West	10/10	6/6 (x3)[a]
2/Day	5/6/06	10:14	Lab	10/10	6/6 (x3)
2/Day	5/31/06	13:54	Materials Mgmt.	10/10	6/6 (x3) 5/6[b]
2/Nights	5/31/06	06:11	4E F-Pod	10/10	6/6 (x3)
2/Nights	6/22/06	06:15	5W A Pod	10/10	6/6 (x3)
2/Evenings	6/14/06	16:00	Housekeeping	10/10	6/6 (x2) 5/6[c]
2/Evenings	6/21/06	16:18	2W	10/10	6/6 (x3)
3/Evening					
3/Evening					
3/Nights	7/27/06	06:19	Roof – AH7[d]	See note d	6/6 (x2)
3/Nights					
3/Day	8/9/06	13:11	Radiology - MRI	9/10[e]	5/6[f]
3/Day					
4/Evening					
4/Evening					
4/Midnights					
4/Midnights					
4/Days					
4/Days					

a = Basement area smoke/fire doors did not close automatically. Work request sent to Facilities.
b = Basement area smoke/fire doors did not close automatically. Work request sent to Facilities.
c = Dietary unaware of need to clear carts from the corridor. Need to reinforce education shared with department.
d = Welding on roof caused actual fire -- smoke entering the building through air handler #7. Phoenix Fire Dept. responded. After action critique held and fire prevention improvements implemented.
e = Issues identified with mis-identification of the device location, Seimens called in to properly identify the area.
f = Overhead announcement not heard in a newly remodeled part of the hospital away from the scene. Appropriate actions taken.
** Drill initiated by slipping into a room and smoking a smoke detector. This gives the nursing staff a chance to practice with the room locator panel in the nurses station.

Figure 28. Fire drill record indicating failure of smoke/fire doors

The second scenario explored was a fire in the northeast end of the second floor. The fire cuts off access to the northeast stairway, and occupants must use the other stairway or west horizontal exit for egress. This scenario was again explored with all doors in the floor-dividing horizontal exit closed, and with one door left open. Figure 29 illustrates the scenario.

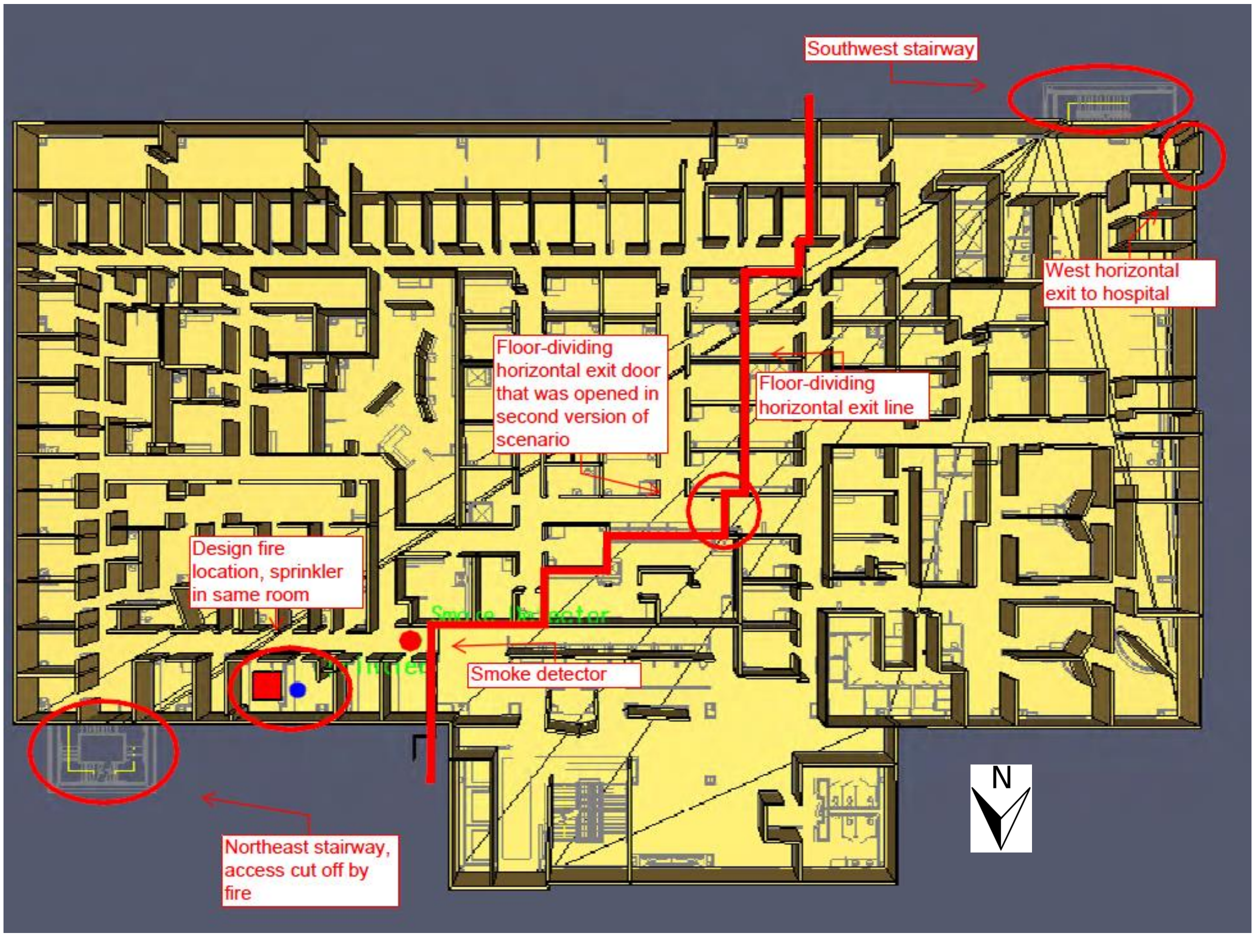

Figure 29. Northeast fire on second floor

The third scenario explored was a fire in the southwest end of the second floor, which cuts off access to the southwest stair and west horizontal exit. This scenario was explored with all doors in the floor-dividing horizontal exit closed, and with one door left open. This scenario is shown in Figure 30.

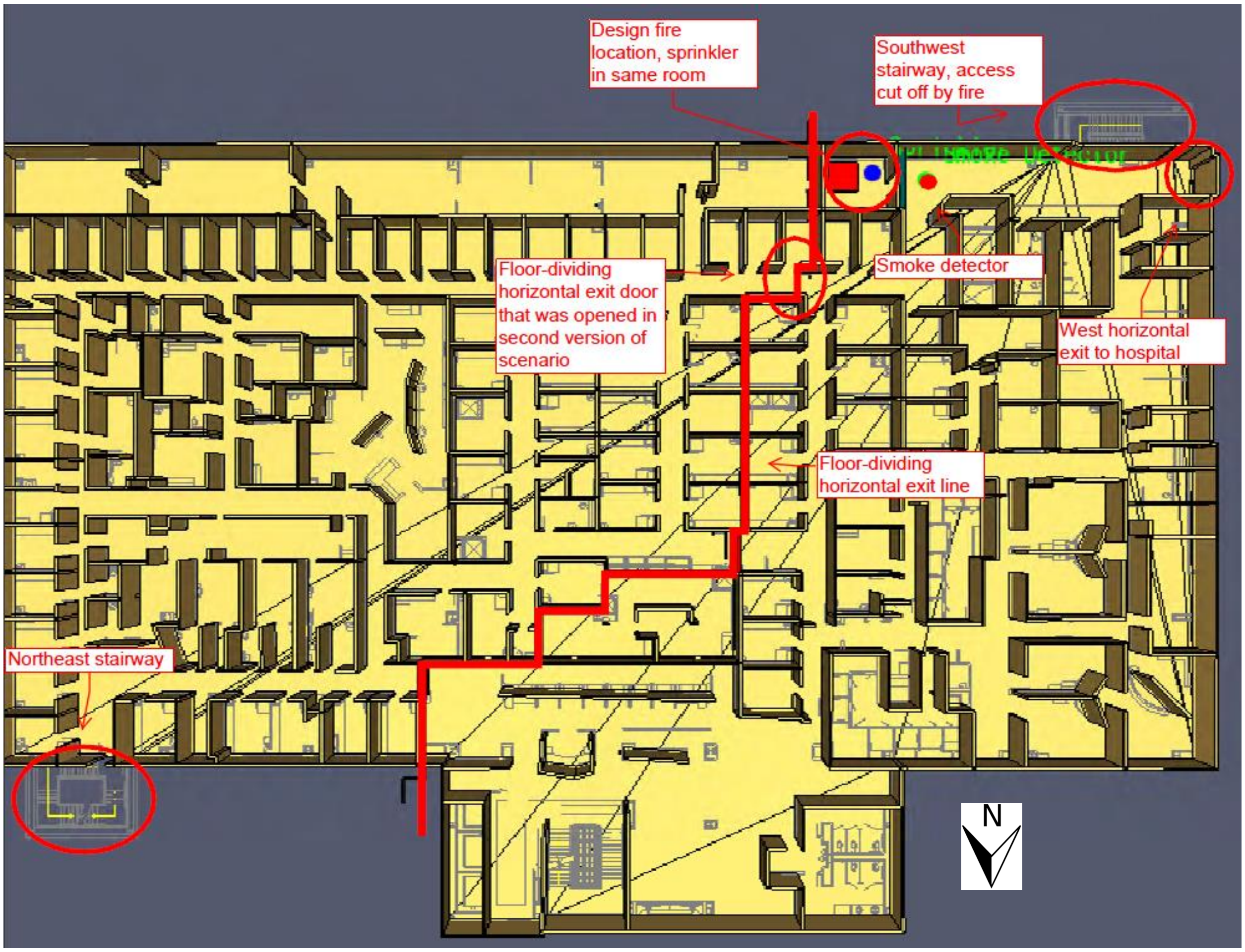

Figure 30. Southwest fire on second floor

The fourth scenario explored was a fire in the northeast end of the third floor that cuts off access to the northeast stairway. Like the other scenarios, this one was modeled both with all floor-dividing horizontal exit doors closed, and with one left open. The fourth scenario is pictured in Figure 31.

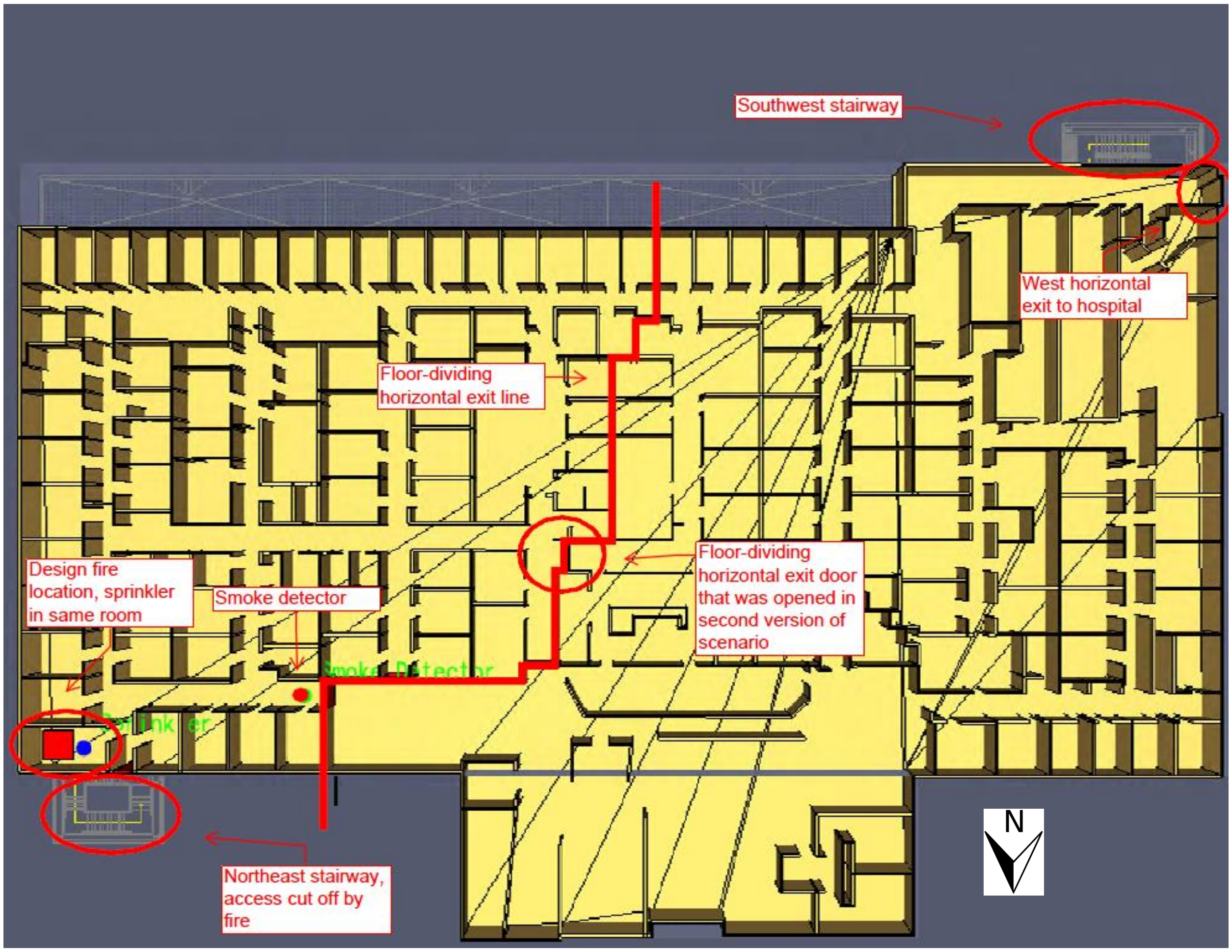

Figure 31. Northeast fire on third floor

The last design fire scenario was a fire in the southwest end of the third floor, cutting off access to the southwest stair and west horizontal exit. The scenario was modeled both with all floor-dividing horizontal exit doors closed, and with one left open. The scenario is shown in Figure 32.

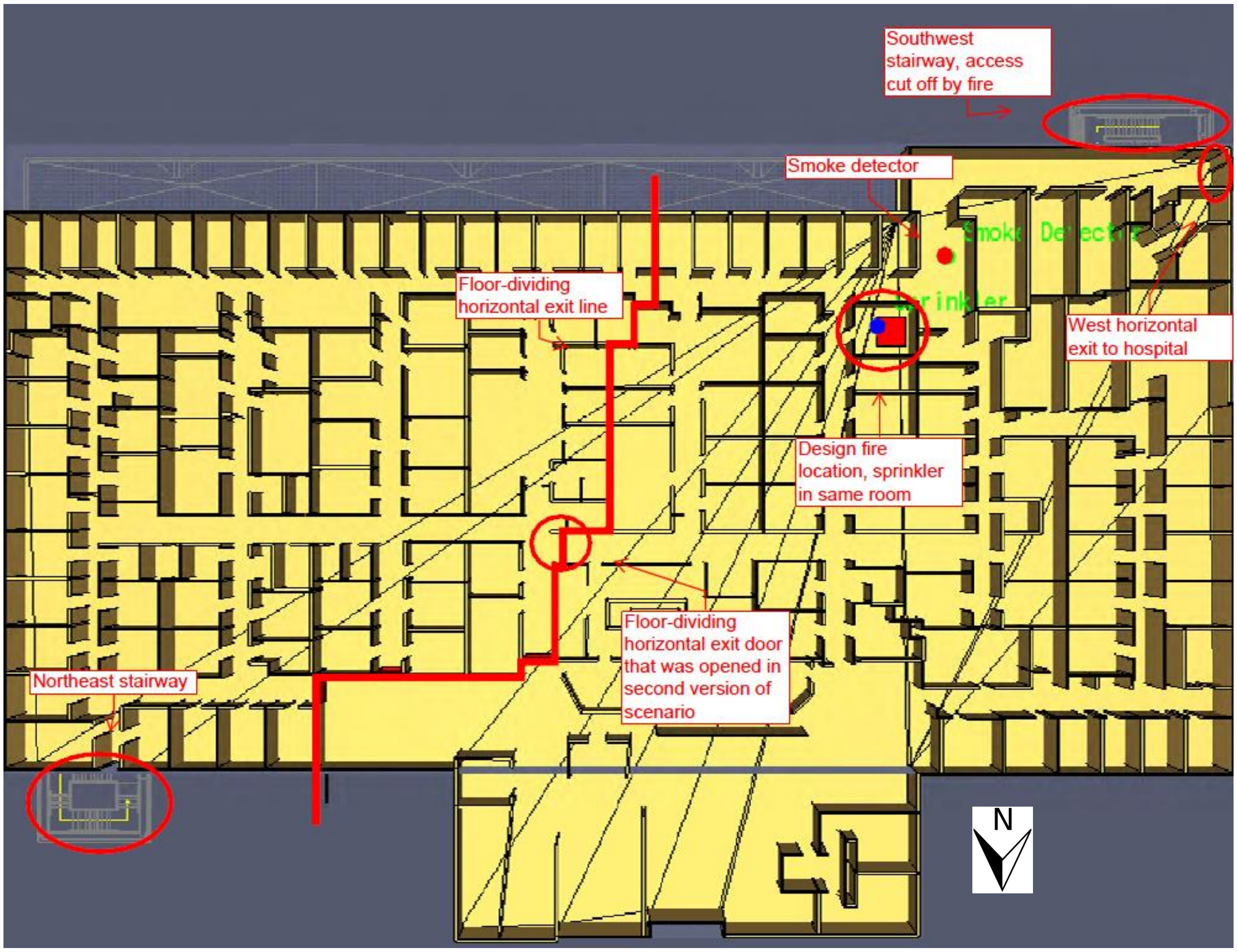

Figure 32. Southwest fire on third floor

Since occupants in the southwest corner of the concourse floor would easily be able to egress across the floor-dividing horizontal exit before tenability is violated, the scenario was not modeled. Since egress is greatly enhanced on the first floor by the presence of the main building exit, this scenario was not modeled either.

35.2. Sprinkler Activation and Heat Release Rate

The assumption was made in the models that the activation of sprinklers would stop the growth of a fire, but not extinguish the fire. This is a conservative assumption that is typically made about sprinkler suppression in fire modeling, since accurately modeling sprinkler suppression using FDS is not yet fully validated. Since the same basic heat release rate growth curve was used in each scenario, and since the offices where the fires were placed were all similar in size, similar sprinkler activation times were achieved. Table 17 summarizes the sprinkler activation times for each model. Table 17 also indicates the heat release rate at which sprinkler activation occurred. The heat release rate was capped at this value throughout the rest of the simulation. Sprinkler activation time was not affected by the status of the floor-dividing horizontal exit doors; the same capped heat release rate was used for both versions of each scenario. Figure 33 provides a graphical representation of the heat release rate history used for each scenario.

Table 17. Sprinkler activation and capped HRR in each design fire scenario

Scenario	Sprinkler Activation Time	Heat Release Rate
Northeast concourse floor	161 seconds	400 kW
Northeast second floor	158 seconds	380 kW
Southwest second floor	136 seconds	290 kW
Northeast third floor	132 seconds	265 kW
Southwest third floor	123 seconds	235 kW

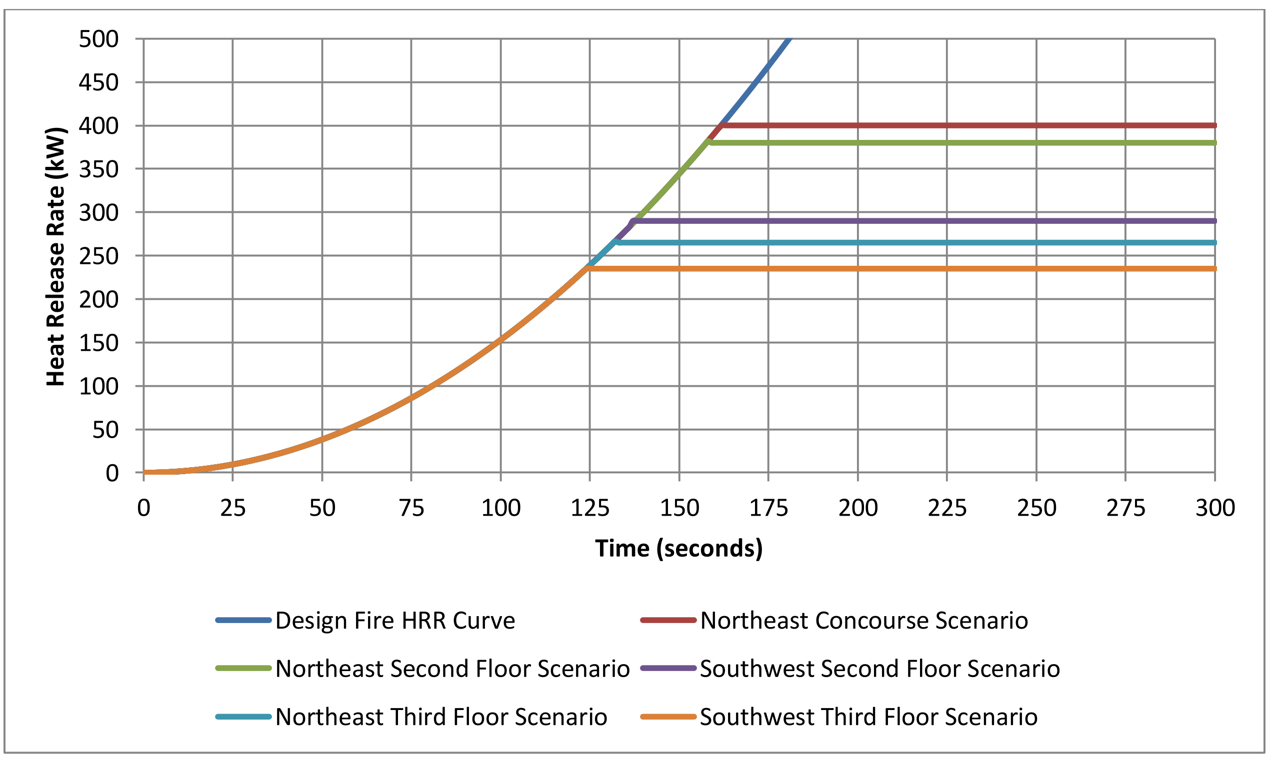

Figure 33. Heat release rate curve for each design scenario

Note that the simulations continue until all occupants have evacuated from the floor, which in every case was longer than 300 seconds.

Because the same fire growth rate was used for each scenario, longer sprinkler activation times lead to larger capped heat release rate values. The northeast concourse floor had the longest sprinkler activation time and consequently the largest capped heat release rate value, because the office used for this fire was larger than the others (in terms of width and length, all offices had the same ceiling height of 9 feet). This allowed a larger space in which fire gases could accumulate and spread out, causing slower growth in upper layer temperatures, and as a result slower sprinkler activation.

In order to verify the sprinkler activation times calculated using FDS, the scenarios were also modeled using DETACT. Table 18 below displays the input parameters into the DETACT model for the Northeast Concourse scenario, and Table 19 displays the respective DETACT and FDS sprinkler activation results for each scenario. The sprinkler activation time predicted by DETACT differs for each model depending on how close the nearest sprinkler is to the design fire.

Table 18. Sample DETACT input parameters (for Northeast Concourse scenario)

INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	2.4	m	R/H	0.833
Radial distance (R)	2.0	m	dT(cj)/dT(pl)	0.339
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.233
Actuation temperature (Td)	74	C	Rep. t2 coeff.	k
Response time index (RTI)	50	(m-s)1/2	Slow	0.003
Fire growth power (n)	2	-	Medium	0.012
Fire growth coefficient (k)	0.0153	kW/s^n	Fast	0.047
Time step (dt)	1	s	Ultrafast	0.400

Table 19. Comparison of FDS and DETACT sprinkler activation time predictions

Scenario	FDS Sprinkler Activ.	DETACT Sprinkler Activ.	Percent Difference
Northeast Concourse	161 seconds	173 seconds	7.5%
Northeast Second	158 seconds	191 seconds	20.8%
Southwest Second	136 seconds	161 seconds	18.4%
Northeast Third	132 seconds	187 seconds	41.7%
Southwest Third	123 seconds	138 seconds	12.2%

As shown in Table 19, the predicted sprinkler activation times differed between the FDS and DETACT models between 7.5% and 41.7%, with DETACT always predicting slower activation than FDS. As shown in a technical report evaluating the prediction capabilities of DETACT[1], for ceiling heights below 3 meters and RTI values below about 160 $(m\text{-}s)^{1/2}$, the agreement between DETACT predictions and actual data tends to worsen, with DETACT over-predicting ceiling temperatures for lower ceilings and lower RTI values. This causes faster detection times to be predicted than would actually occur. As shown in a report evaluating the prediction capabilities of FDS[2], at ceiling heights of 2.4 meters, FDS tends to slightly over-predict ceiling temperatures. However, for RTI values above 30 $(m\text{-}s)^{1/2}$, grid resolution of about 4 inches, and C-values for sprinkler temperature links of 0, FDS tends to over-predict sprinkler activation times, which is conservative for design purposes. These are very similar parameters to those used in the MCS Building simulations (50 $(m\text{-}s)^{1/2}$ RTI values were used for the sprinklers in the MCS Building).

Although the DETACT modeling suggests that sprinkler activation times will be longer than those predicted by FDS, the research suggests that DETACT may not be applicable for low ceiling heights and low RTI values. The research on FDS predictions of sprinkler activation times, especially for models with similar parameters to those used for the MCS Building models, suggests that FDS tends to produce conservative estimates.

For these reasons, the sprinkler activation times predicted using the MCS Building models will be assumed to be valid.

35.3. Smoke Detector Activation

The nearest smoke detector to each design fire location was included in the models, in order to produce an estimate of when the fire alarm system will activate. It is important to have an estimate of this time so that an estimate can be made of when egress will begin. The smoke detectors used in the simulations utilize the Cleary Photoelectric model.

Research investigating smoke detector activation times predicted by FDS[3] has compiled the results of several experimental programs. This was done in terms of cumulative percentages of detectors activated, as a function of percent obscuration. The worst-case 80th percentile detector response for all studies of photoelectric smoke detectors was 12 %/ft. For this reason, a percent obscuration level of 35 %/m (about 12 %/FT) was used for the smoke detector activation criterion in the MCS Building simulations.

It was not possible to verify smoke detector activation using DETACT as it was with the sprinkler activation times. This is because smoke detectors are not placed in the same room as the design fires. Smoke detectors will activate before sprinklers, so placing the design fire in a space without smoke detection results in a worst-case scenario in terms of automatic fire detection. Because the smoke detectors are not located in the same room as the fire, there are ceiling obstructions and various irregular ceiling and wall geometries between the design fire and the nearest smoke detector. For this reason, it was not possible to model smoke detector activation accurately with DETACT.

[1] Hurley et. al., "Evaluation of the Computer Fire Model DETACT-QS", Performance-Based Codes and Fire Safety Design Methods, 4th International Conference, Melbourne, March 20, 2002.

[2] Bittern, A., "Analysis of FDS Predicted Sprinkler Activation Times with Experiments", University of Canterbury, Christchurch, New Zealand, April 8, 2004.

[3] Mowrer, F., et. al., "Validation of a Smoke Detection Performance Prediction Methodology: Status Report", Fire Protection Research Foundation, October 2008.

A summary of the FDS-predicted smoke detector activation times is shown below in Table 20. Sprinkler activation times for each scenario are included for comparison.

Table 20. Smoke detector activation times predicted using FDS

Scenario	Smoke Detector Activation	Sprinkler Activation
Northeast Concourse	85 seconds	173 seconds
Northeast Second	125 seconds	191 seconds
Southwest Second	77 seconds	161 seconds
Northeast Third	135 seconds	187 seconds
Southwest Third	250 seconds	138 seconds

As shown by Table 20, the smoke detectors in each scenario typically activated before the sprinklers, with the notable exception of the Southwest Third Floor scenario. By comparing Figure 27 through Figure 32, it can be seen that the smoke detector in the Southwest Third Floor scenario (Figure 32) is more remote from the design fire room than in the other scenarios. The smoke must travel out of the design fire room, and turn 3 corners before reaching the smoke detector, while in every other scenario the smoke must only turn a single corner to reach a corridor with a smoke detector. This explains the longer detection time in the Southwest Third Floor scenario compared to the other design fire scenarios.

Activation of a smoke detector will trigger the positive alarm sequence (see "MCS Building EVAC System and Evacuation Procedure" above). The maximum delay before the fire alarm system will activate after smoke detection is 15 seconds. Therefore, for the Pathfinder evacuation models, the detection time for each scenario plus 15 seconds was used as a delay time before occupants would begin evacuating.

35.4. Tenability Analysis of Design Fire Scenarios

A summary of the findings of each design fire is shown below in Table 21. The only situation in which tenability was determined to be violated in the models was the visibility criterion in the Southwest Third Floor model. The reason for this was because visibility fell below 35 feet in the area where occupants are queueing to use the only available stairway. A screenshot of the scenario is shown in Figure 34. Although this is concerning, it should be noted that visibility is still around 7 meters (23 feet) which is more than enough visibility for occupants at the back of the queue to see the horizontal exit door, which has an illuminated exit sign above it. It is very likely that the occupants in the back of the queue will still be able to successfully make their way to the northeast stairway, even though their visibility has fallen below the 35 foot tenability criterion.

Table 21. Summary of design fire scenario results

Scenario	Time to Reach Horizontal Exit	Time to Evacuate Floor	Horizontal Exit Door Opened?	Toxicity Violated?	Visibility Violated?	Thermal Effects Violated?
Northeast Concourse	176 sec.	382 sec.	No	No	No	No
			Yes	No	No	No
Northeast Second	149 sec.	403 sec.	No	No	No	No
			Yes	No	No	No
Southwest Second	216 sec.	778 sec.	No	No	No	No
			Yes	No	No	No
Northeast Third	132 sec.	392 sec.	No	No	No	No
			Yes	No	No	No
Southwest Third	735 sec.	946 sec.	No	No	No	No
			Yes	No	Yes	No

Figure 34. Southwest Third Floor (horizontal exit door open) model results

Another important factor to consider is the presence of the staff, who are trained in evacuation procedures and location of exits, and who will be guiding the occupants during the evacuation. These staff members can potentially re-organize the queueing so that all occupants are on the east side of the floor-dividing horizontal exit. It can be seen from Figure 34 that there is more than enough room on the east side of the floor-dividing horizontal exit for the entire queue to fit, if it were re-organized.

A third factor to consider is that even though visibility has been lost in this area, loss of visibility in and of itself will not truly incapacitate occupants so that they are unable to escape (especially with the presence of the staff, who know the location of exits). Loss of visibility is also not lethal. Even though visibility falls below 35 feet, the other two tenability criteria, whose violation may result in incapacitation, are not violated. The carbon monoxide concentrations are shown in Figure 35, and the temperatures are shown in Figure 36.

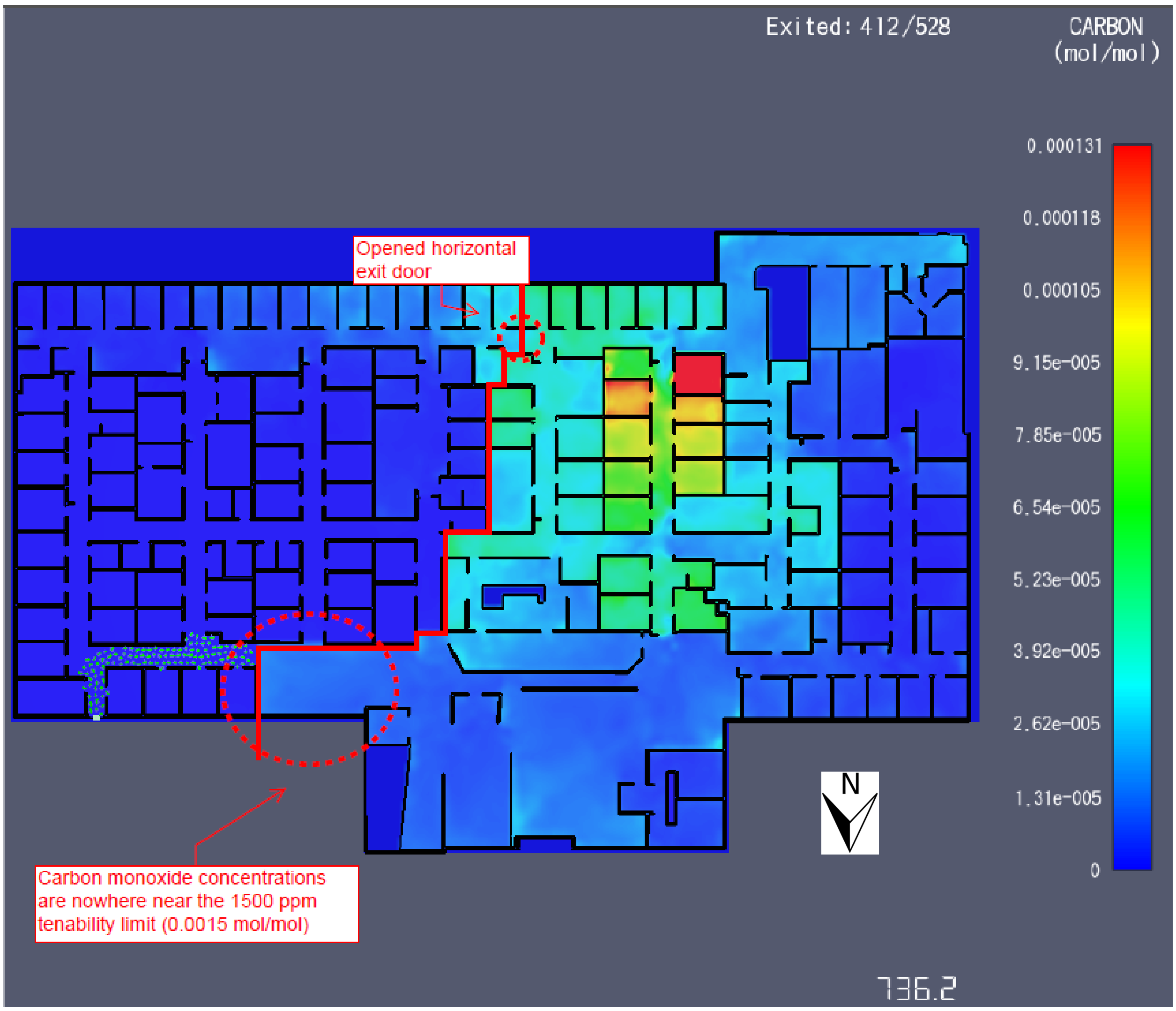

Figure 35. Southwest Third Floor toxicity tenability analysis

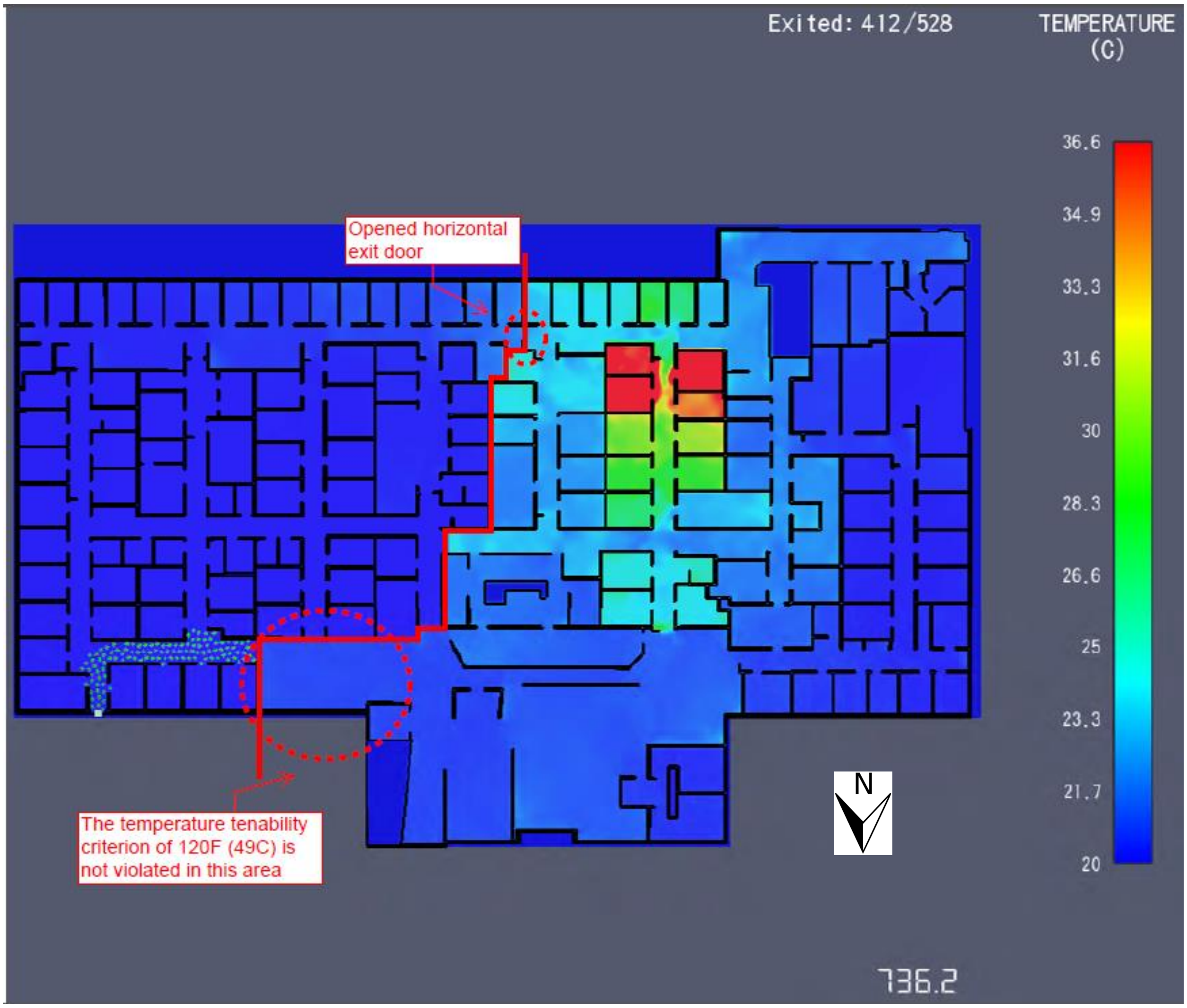

Figure 36. Southwest Third Floor thermal effects tenability analysis

Therefore, even though the visibility criterion was violated in this scenario, it is not a significant concern regarding life safety. Trained staff will be available to re-organize queueing so all evacuating occupants are protected by the 2-hour rated horizontal exit, toxicity and thermal effects tenability are not violated, and occupants still have enough visibility in the back of the queueing group to see exit signs leading to the northeast stairway.

As was previously stated, the tenability analysis used for this report utilized an egress flow approach. The Pathfinder evacuation model results and Pyrosim fire modeling results were combined to try and determine areas where tenability is violated in areas where occupants are simultaneously trying to evacuate. Using this approach, the only scenario in which tenability was violated was the Southwest Third Floor model, discussed above. However, it is important to state that this was the only situation in which tenability was violated *on the egress flow approach* used. Tenability criteria were violated in other areas where the evacuation model did not predict occupants would be located. Although the evacuation model did not predict that occupants would be located in these areas, it is possible that occupants could be stuck in these areas due to extended pre-movement times, getting lost trying to find an exit, impaired mobility, or other reasons. This is important to realize, because although the tenability analysis conducted using the egress flow approach shows that it is unlikely for life safety to be compromised, occupants who are unable to evacuate in the orderly fashion that the Pathfinder model predicts may still be in danger.

Considering tenability on a defend-in-place basis, all of the modeling scenarios predict that the toxicity criterion will not in violated on the majority of any floor (at least for the time needed to normally fully evacuate the floor). It cannot be guaranteed that toxicity tenability will not be violated in the design fire room, but the models do show that toxicity is not violated in the remainder of the floor. An example of this is shown in Figure 37.

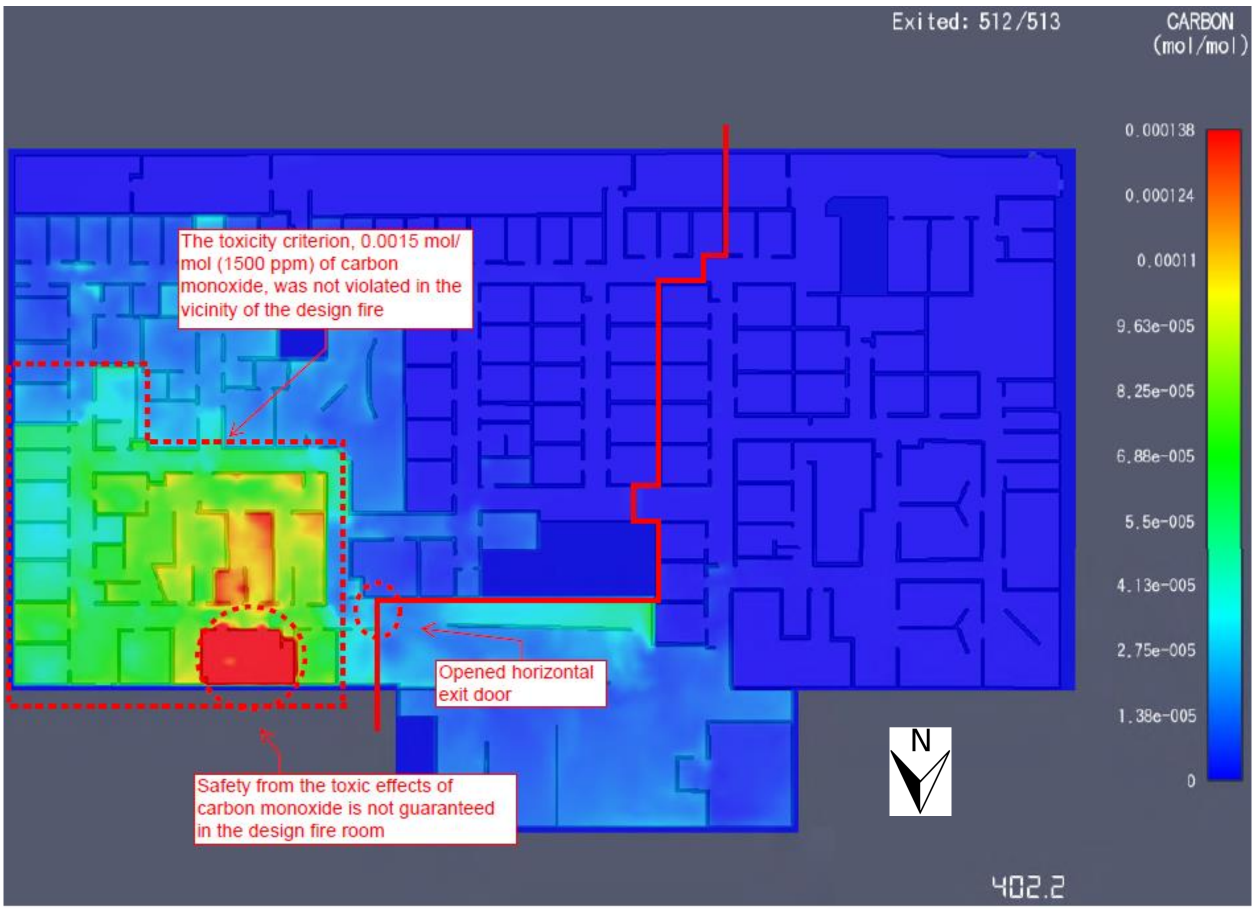

Figure 37. Northeast Second Floor toxicity tenability analysis

As shown by Figure 37, while safety from carbon monoxide toxicity is not guaranteed in the design fire room or right outside that room, the toxicity tenability criterion is not violated in the vicinity of the design fire area. For an occupant experiencing extended pre-movement times, who may still be on the east side of the horizontal exit after 403 seconds, incapacitation or death from carbon monoxide poisoning is unlikely.

A similar conclusion is reached about the thermal effects tenability criterion. An example is shown in Figure 38.

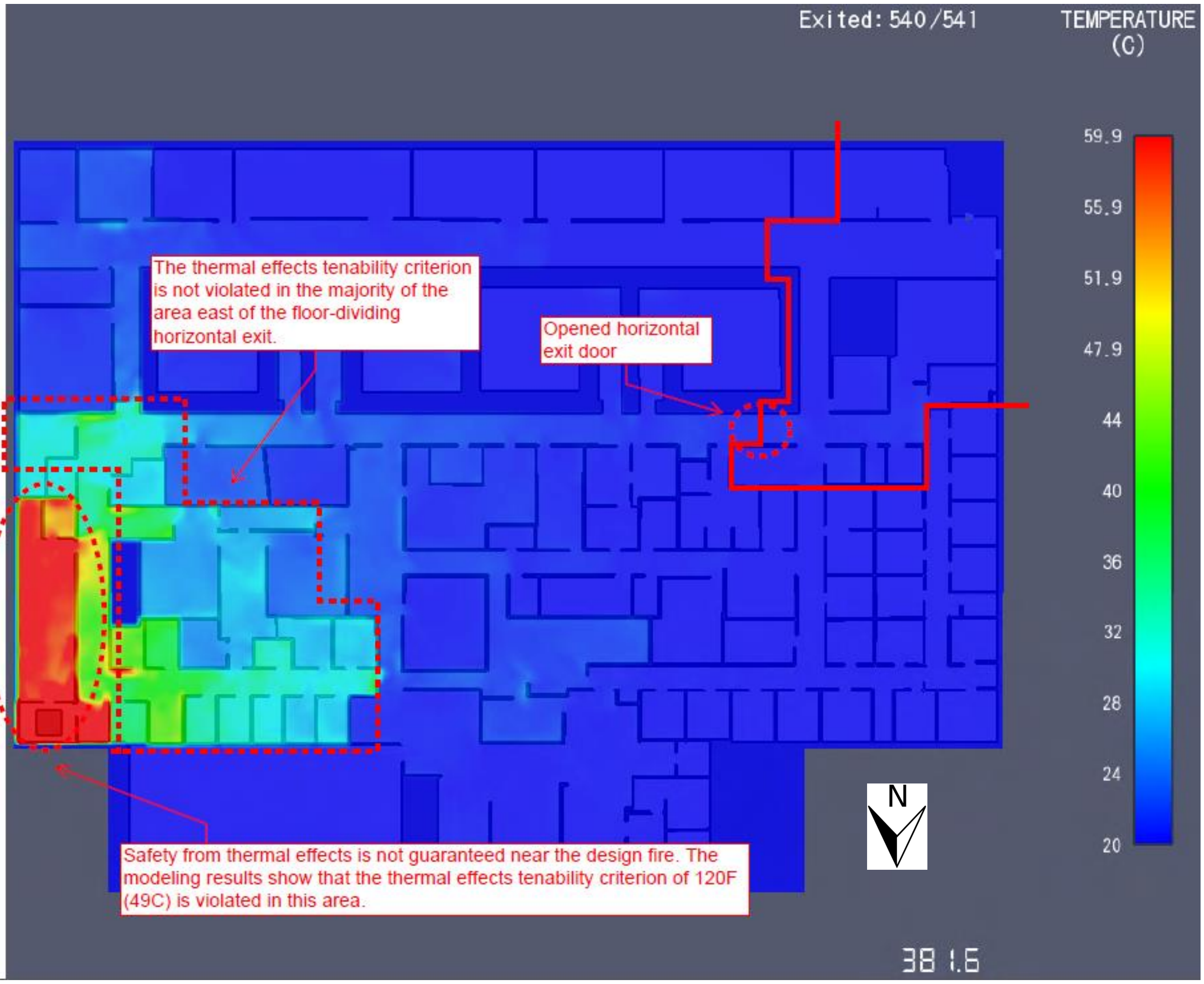

Figure 38. Northeast Concourse Floor thermal effects tenability analysis

Like the toxic effects analysis, safety from thermal effects is not guaranteed in the design fire room or immediately outside the room. However, modeling indicates that the thermal effects tenability criterion is not violated in a majority of the area east of the floor-dividing horizontal exit. For an occupant experiencing extended pre-movement times or having difficulty evacuating normally, danger from thermal effects is not a significant concern.

Toxic and thermal effects have been demonstrated from modeling efforts to not be a significant concern for occupants experiencing difficulty evacuating, who are stuck on the fire side of the floor-dividing horizontal exit. However, visibility *is* seriously impaired under these conditions. An example is shown below in Figure 39.

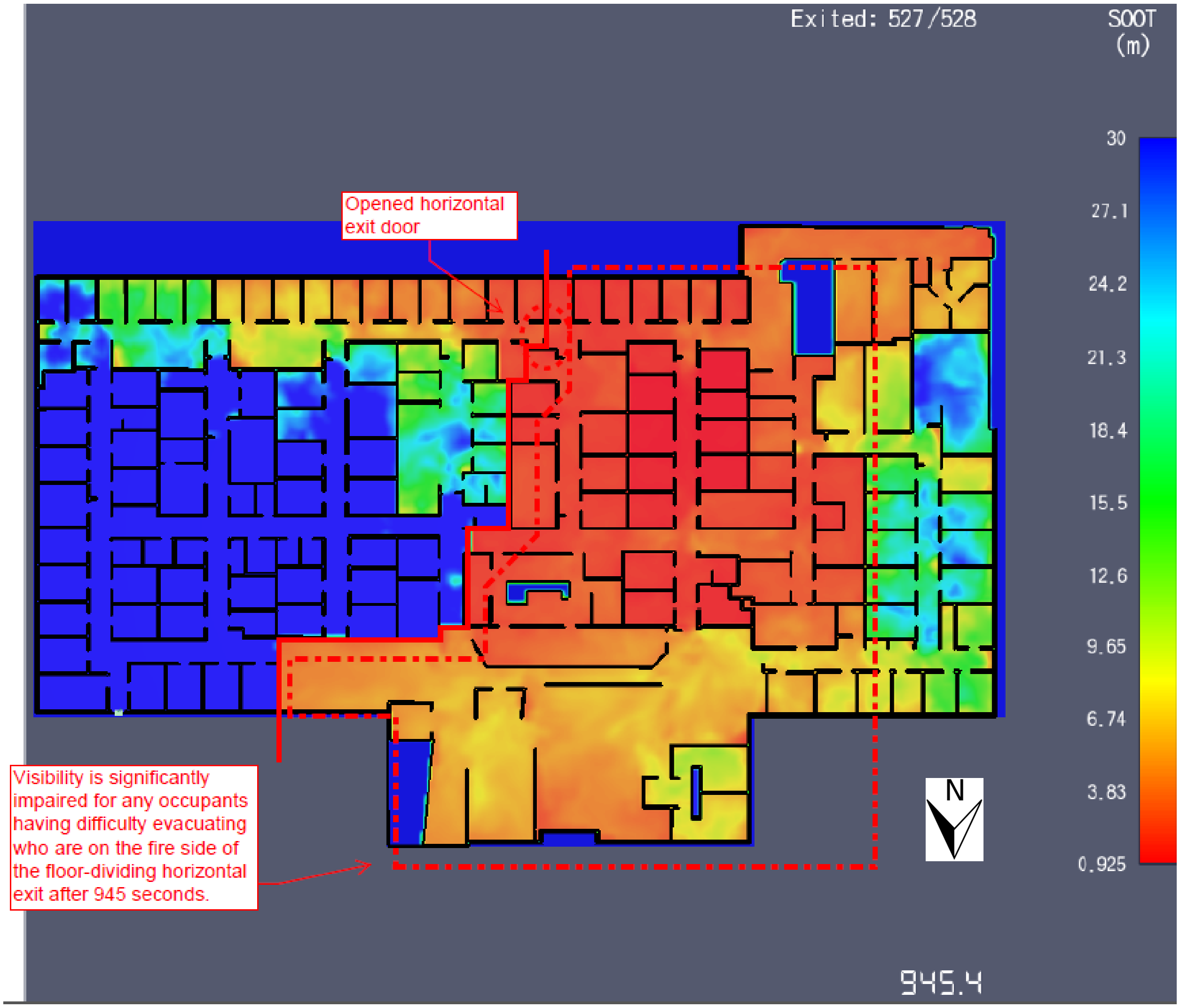

Figure 39. Southwest Third Floor visibility tenability analysis

Figure 39 clearly shows that visibility is significantly impaired for occupants experiencing difficulty who may be stuck on the fire side of the horizontal exit. Even though they are not in immediate danger from toxicity or thermal effects, they may not be able to find their way to an exit on their own.

Visibility impaired to the degree shown in Figure 39 leads to another important conclusion. Although toxicity and thermal effects are not an immediate threat for occupants having difficulty evacuating, *this is only true to the extent shown by the models*. The simulations were only run for the time needed to complete a floor evacuation, as predicted by Pathfinder. It is entirely possible that toxicity and/or thermal effects criteria could be violated much later in the simulation, assuming the fire continues burning. Heavily impaired visibility, preventing occupants from finding an exit for long periods of time, may be an issue for this reason.

A collection of annotated screenshots used in the tenability analysis are presented in Appendix P.

36. Performance-based Analysis Summary

The performance-based analysis of the MCS Building design fires provides several important insights.

The selection of the design fire was based on actual data supplied by the NIST 9/11 workstation fire tests, which should closely approximate fuel loads typically present in the MCS Building. The design fire location was conservatively chosen with respect to blocking exits, slow detection times in rooms without smoke detectors, and the likely presence of large fuel loads. The product yields of the design fire were approximated using data from the SFPE Handbook, and the heat release rate history of the design fire was taken directly from the NIST data.

The design fire increases in heat release rate in each scenario up until the point of sprinkler activation. The sprinklers may be able to suppress the fire, or limit its ability to spread to other fuels, and thus eventually cause extinguishment. However, for conservative design purposes, sprinkler activation was assumed to stop the growth of the fire at a certain heat release rate, but not to cause suppression. The fire was assumed to burn at the "capped" heat release rate indefinitely through the remainder of the simulations.

The spread of the fire products was modeled throughout the fire floor in each simulation using Pyrosim. The evacuation of occupants on the floor was modeled using Pathfinder, including a delay time (caused by the positive alarm sequence and detection time). By combining the results of the two models, tenability could be analyzed on an egress flow basis. Tenability analyzed in this way showed that the only scenario in which tenability criteria were violated was the Southwest Third Floor model. Visibility was impaired below 35 feet in the group of queueing occupants, but this was determined to not be a critical life safety issue. This is supported by the fact that the queueing occupants still have enough visibility to see exit signs leading to the northeast stairway, combined with the fact that trained staff will assist with evacuation and the re-organization of queueing occupants.

The models also provided insights regarding occupants with extended pre-movement times, impaired mobility, or wayfinding issues. Toxicity and thermal effects tenability criteria were shown not to be violated on the majority of any floor, at least up to the time needed to normally fully evacuate the floor. However, visibility was shown to be greatly impaired in areas on the fire side of the floor-dividing horizontal exits. This means that toxicity and thermal effects may become a concern at times exceeding the floor evacuation time predicted by Pathfinder, if occupants first experience impaired evacuation, and consequently greatly reduced visibility.

These concerns are mitigated by the fact that the MCS Building is equipped with an emergency voice/alarm communication system, as well as having staff trained in evacuation procedures. Therefore, occupants should not experience major difficulties with evacuation before tenability is violated.

37. Conclusion and Recommendations

This report presents a comprehensive evaluation of the fire protection and life safety features of the Mayo Clinic Specialties Building under the requirements of the 2012 PBCC and PFC.

A prescriptive analysis was first performed, evaluating the PBCC and PFC requirements for the structural fire protection, suppression systems, detection and alarm systems, and egress features. As a Type I-A construction building, with a separated mixed-use occupancy, the MCS Building is compliant with the PBCC and PFC requirements for structural fire protection. Its suppression systems were designed from scratch since no existing sprinkler plans were available; the sprinkler system was designed according to the requirements of the 2013 edition of NFPA 13 and will be inspected, tested, and maintained in accordance with the requirements of the 2013 edition of NFPA 25. The egress features in the building satisfy all applicable PBCC and PFC requirements.

The fire alarm and detection systems in the building are designed and installed in accordance with the 2013 edition of NFPA 72. However, there are some minor areas of concern with the fire alarm and detection system. Room 2-229 and Room 3-539 should be inspected to ensure that they are provided with adequate candela ratings. Room C-201B is not yet divided from the adjoining office by partitions, but when it is divided, it should be ensured that it is provided with both visible and audible notification. In addition, area smoke detection needs to be provided in the new linear accelerator rooms on the concourse level when they are put into service.

Following the prescriptive analysis, a performance-based analysis was conducted to investigate the ability of the fire protection and life safety features in the building to perform under challenging fire scenarios. Models using the Pathfinder and FDS computer programs were built, and several different design fire scenarios were investigated. Tenability was analyzed primarily using an egress flow basis, by combining the results of the computer models. The only instance where tenability was violated on this basis was the Southwest Third Floor scenario, where the visibility criterion of 35 feet was violated in the vicinity of queueing occupants. For reasons presented in the analysis, this was determined not to be a critical issue for life safety. Staff training is critical to successful evacuation, so that the horizontal exits are used correctly, and so occupants are guided directly to the appropriate exit. Regular fire drills and refresher training sessions should continue to be implemented for the staff in the building.

All fire protection systems are installed in accordance with the appropriate codes and standards. If the above recommendations are followed, and all fire protection systems are inspected, tested, and maintained appropriately, the MCS Building fire safety systems should perform satisfactorily in a reasonably expected fire scenario.

38. References

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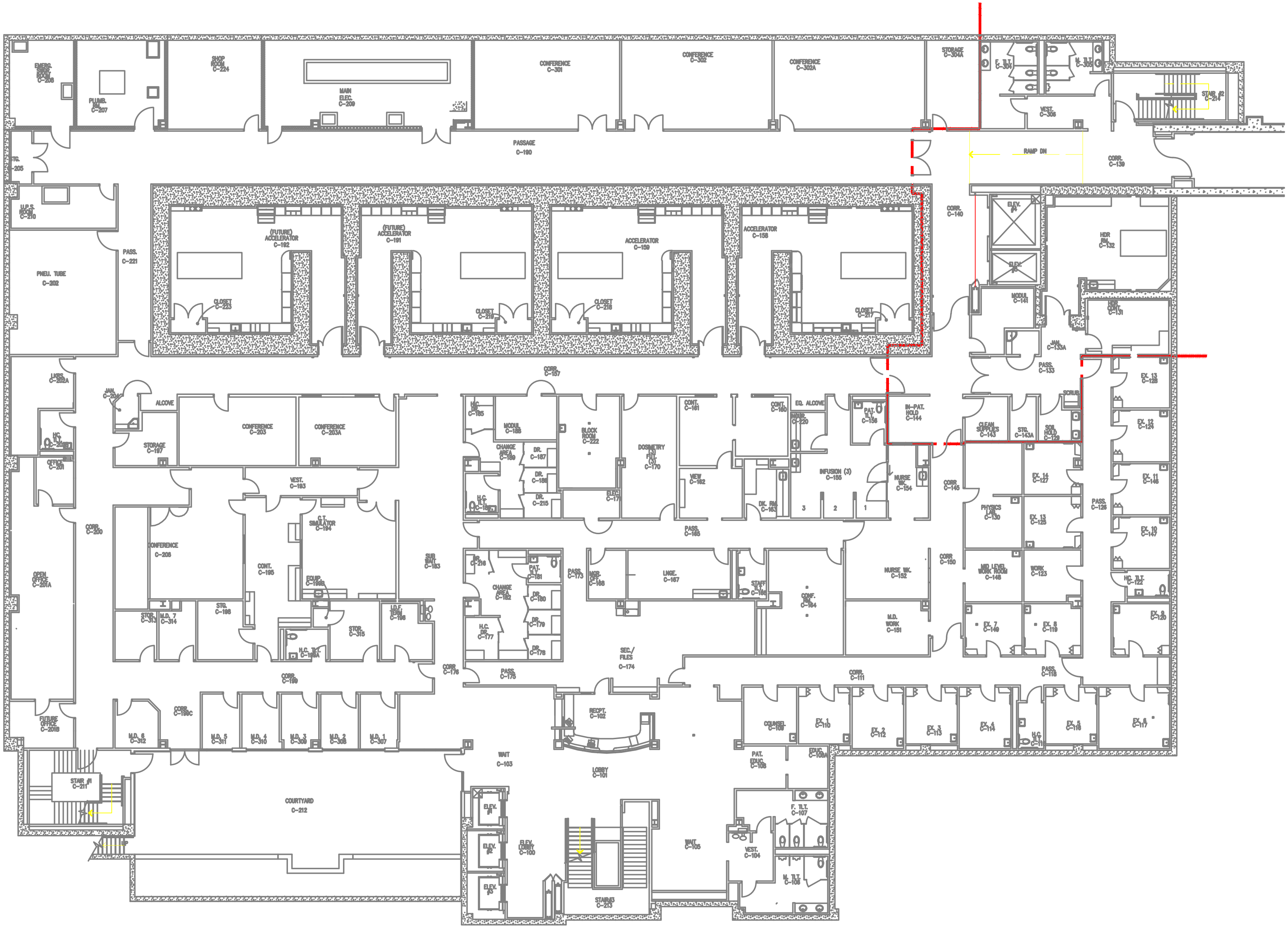
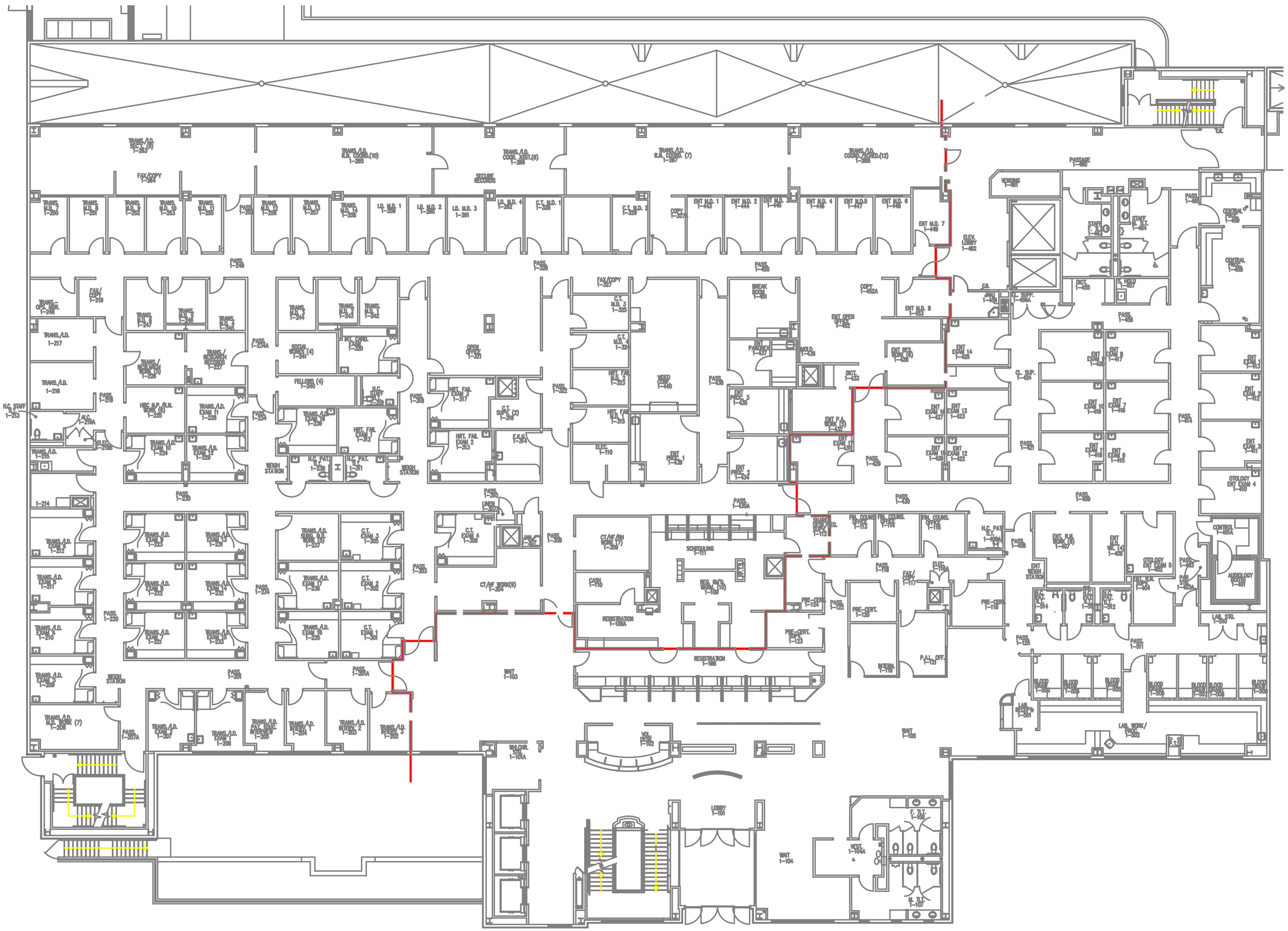
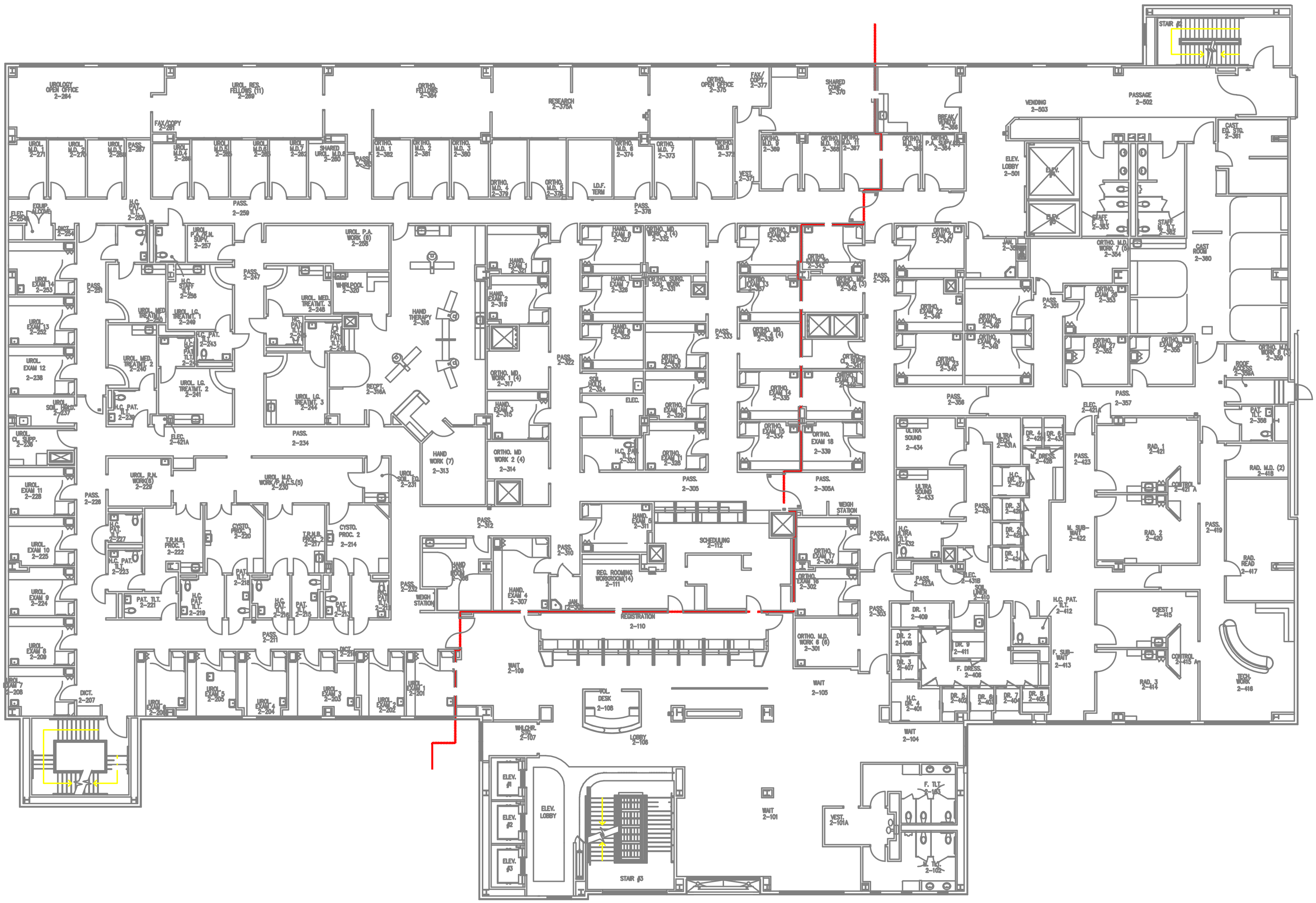
Appendix A

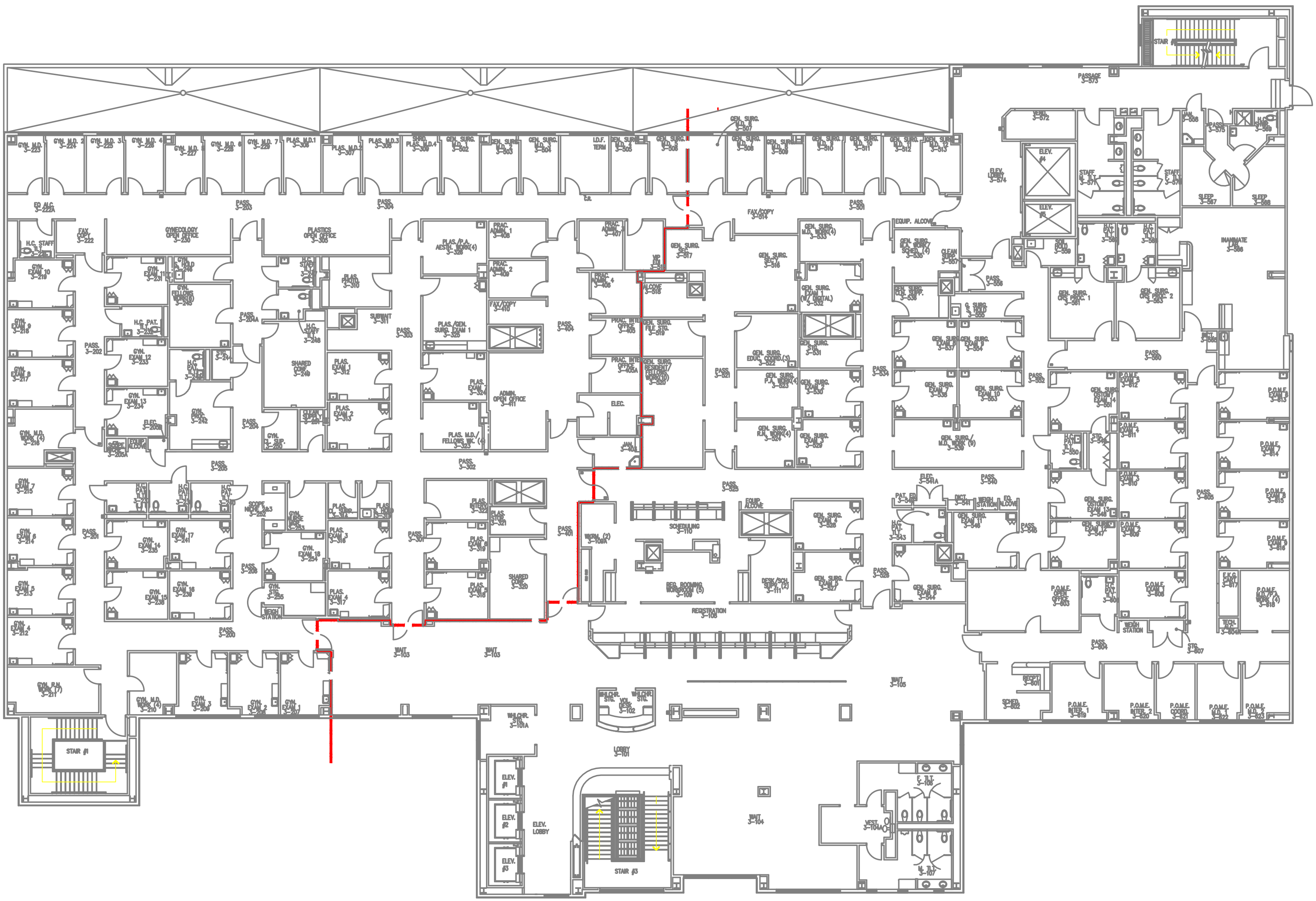


PASSAGE
C-190
RAMP DN
CORR.
C-139
CORR.
C-140
ACCELERATOR
C-159
ACCELERATOR
C-158
(FUTURE)
ACCELERATOR
C-192
(FUTURE)
ACCELERATOR
C-191
CONFERENCE
C-301
CONFERENCE
C-302
CONFERENCE
C-302A
MAIN
ELEC.
C-209
SHOP
ROOM
C-224
PNEU. TUBE
C-202
CONFERENCE
C-203
CONFERENCE
C-203A
ALCOVE
STORAGE
C-197
INFUSION (3)
C-155
NURSE WK.
C-152
M.D.
WORK
C-151
SEC./
FILES
C-174
RECPT.
C-102
WAIT
C-103
LOBBY
C-101
COURTYARD
C-212
STAIR #1
C-211
STAIRS
C-213
WAIT
C-105
VEST.
C-104
CORR.
C-111



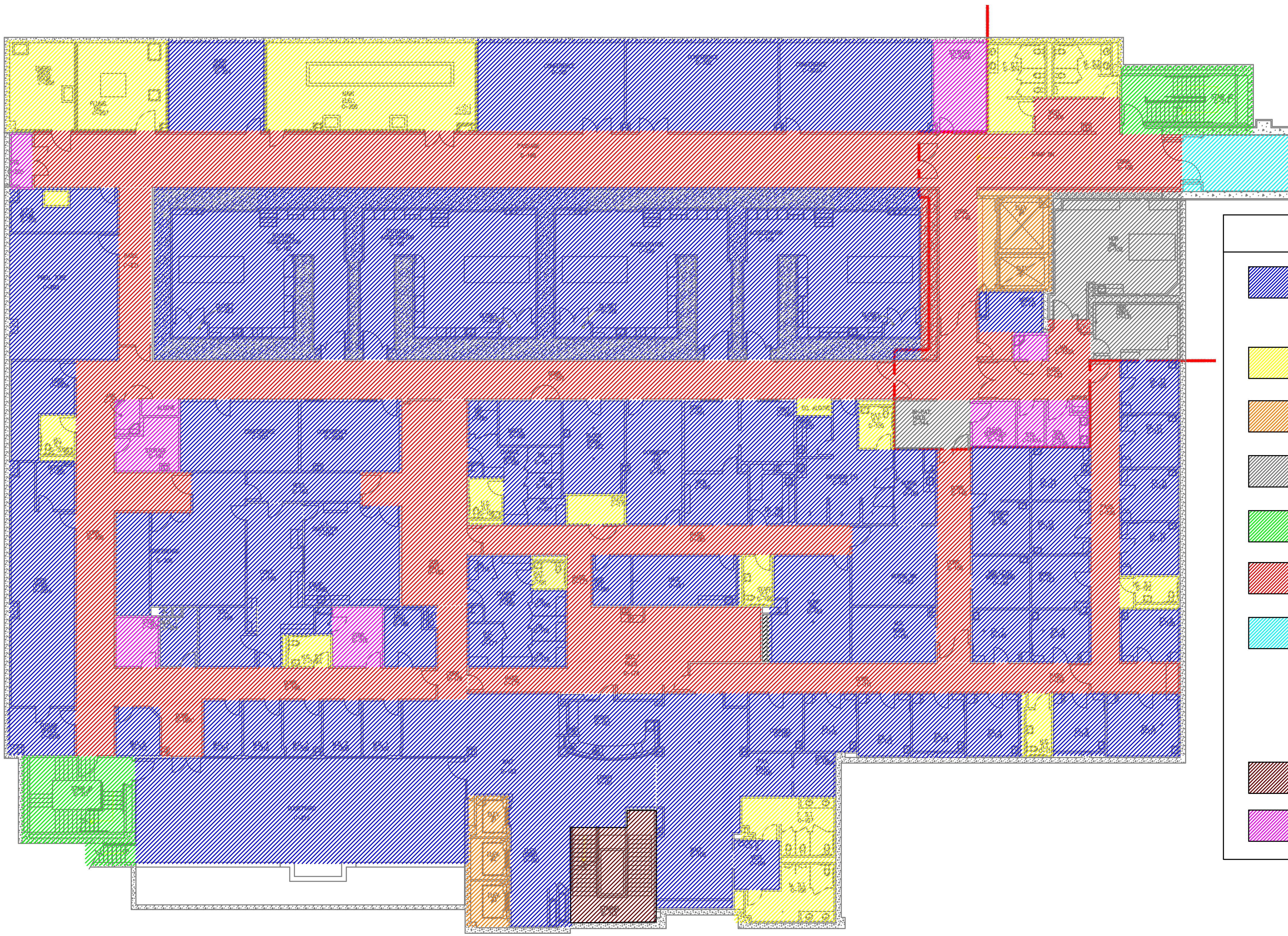


PASSAGE 2-502
VENDING 2-503
HAND THERAPY 2-316
SCHEDULING 2-112
REGISTRATION 2-110
WAIT 2-109
WAIT 2-105
LOBBY 2-106
WAIT 2-104
WAIT 2-101
ELEV. LOBBY
STAIR #3



Appendix B

CONCOURSE FLOOR



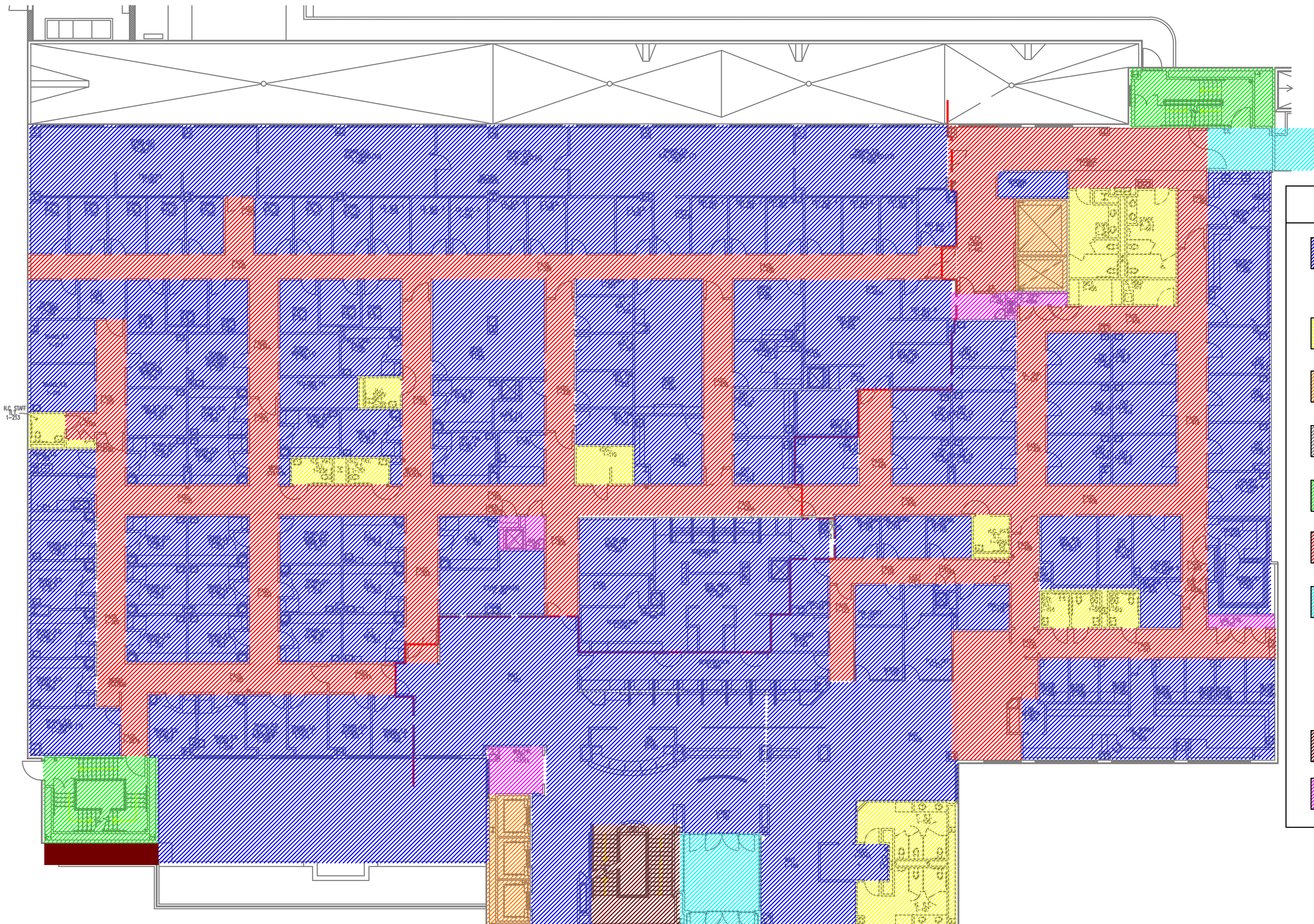
LEGEND

- GROUP B (MEDICAL OFFICES, OUTPATIENT CLINICS)
- ACCESSORY OR INCIDENTAL
- ELEVATORS (NOT FOR EGRESS)
- GROUP I-2 (INPATIENT TREATMENT)
- INTERIOR EXIT STAIRWAYS
- EXIT ACCESS
- HORIZONTAL EXIT

NOTE: DASHED RED LINE INDICATES HORIZONTAL EXIT DIVIDING FLOOR.

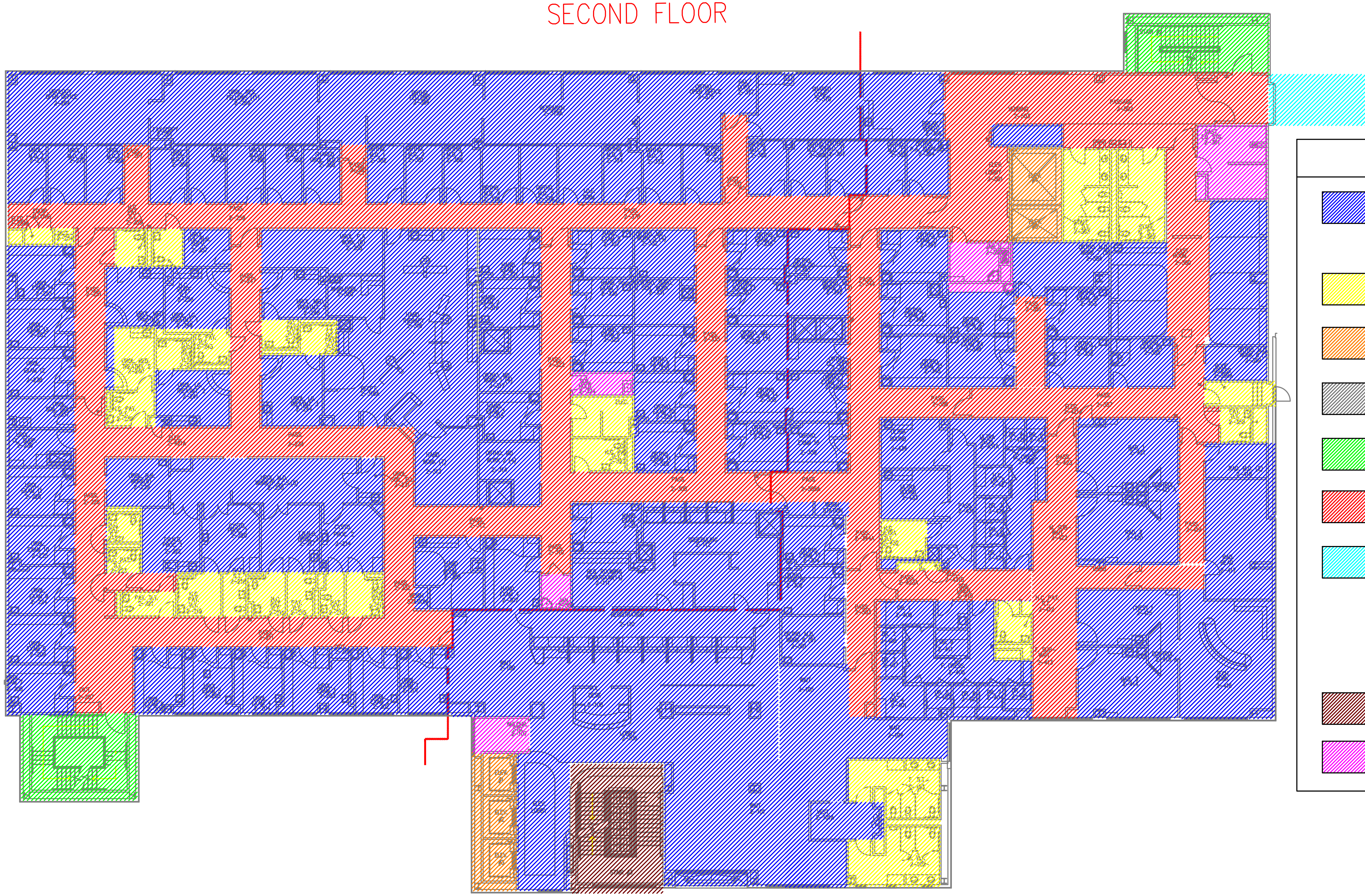
- STAIRWAY (NOT FOR EGRESS)
- GROUP S-2, ACCESSORY TO GROUP B

FIRST FLOOR



LEGEND
GROUP B (MEDICAL OFFICES, OUTPATIENT CLINICS)
ACCESSORY OR INCIDENTAL
ELEVATORS (NOT FOR EGRESS)
GROUP I-2 (INPATIENT TREATMENT)
INTERIOR EXIT STAIRWAYS
EXIT ACCESS
HORIZONTAL EXIT
NOTE: DASHED RED LINE INDICATES HORIZONTAL EXIT DIVIDING FLOOR.
STAIRWAY (NOT FOR EGRESS)
GROUP S-2, ACCESSORY TO GROUP B

SECOND FLOOR



LEGEND

- GROUP B (MEDICAL OFFICES, OUTPATIENT CLINICS)
- ACCESSORY OR INCIDENTAL
- ELEVATORS (NOT FOR EGRESS)
- GROUP I-2 (INPATIENT TREATMENT)
- INTERIOR EXIT STAIRWAYS
- EXIT ACCESS
- HORIZONTAL EXIT

NOTE: DASHED RED LINE INDICATES HORIZONTAL EXIT DIVIDING FLOOR.

- STAIRWAY (NOT FOR EGRESS)
- GROUP S-2, ACCESSORY TO GROUP B

THIRD FLOOR

LEGEND

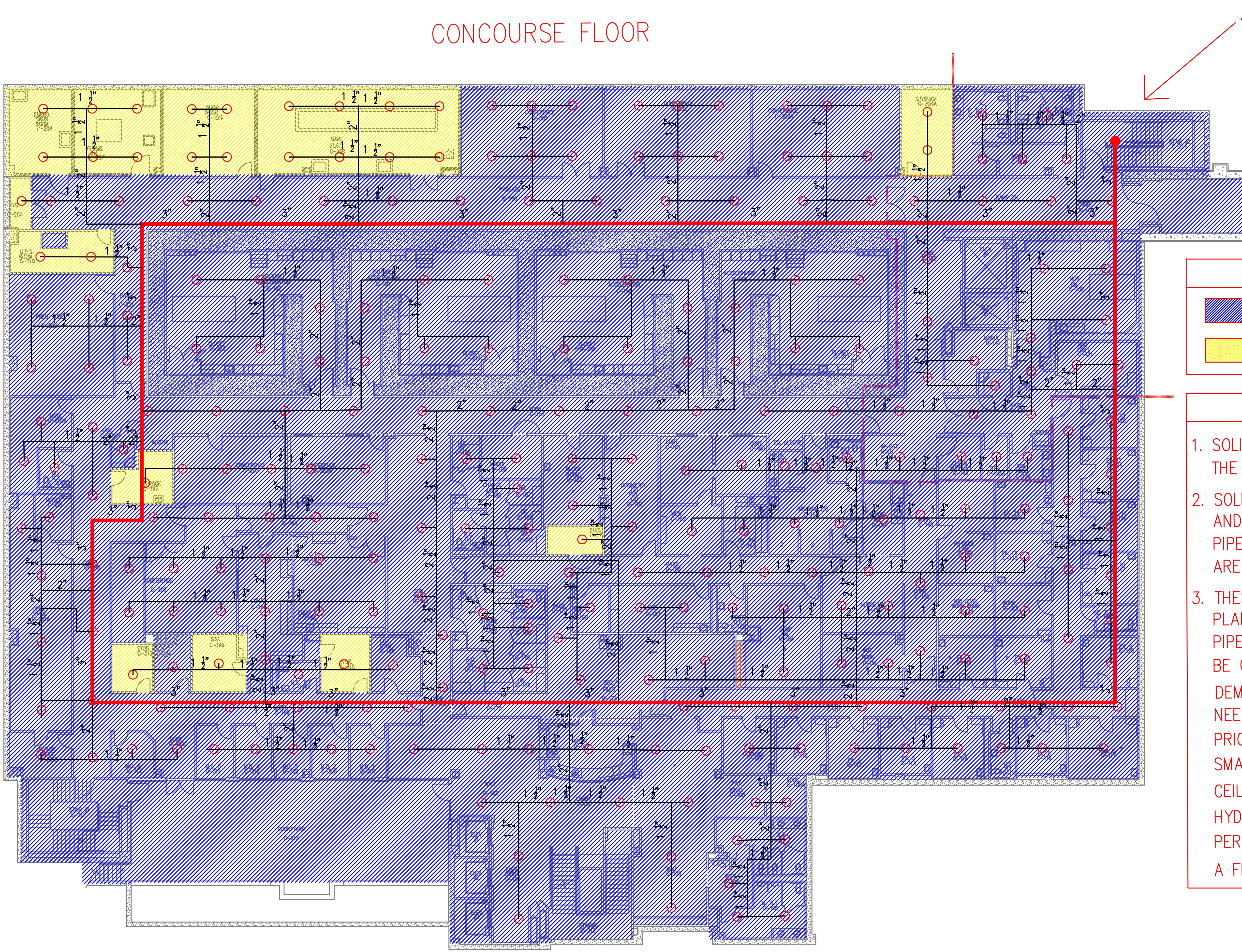
- GROUP B (MEDICAL OFFICES, OUTPATIENT CLINICS)
- ACCESSORY OR INCIDENTAL
- ELEVATORS (NOT FOR EGRESS)
- GROUP I-2 (INPATIENT TREATMENT)
- INTERIOR EXIT STAIRWAYS
- EXIT ACCESS
- HORIZONTAL EXIT

NOTE: DASHED RED LINE INDICATES HORIZONTAL EXIT DIVIDING FLOOR.

- STAIRWAY (NOT FOR EGRESS)
- GROUP S-2, ACCESSORY TO GROUP B

Appendix C

CONCOURSE FLOOR

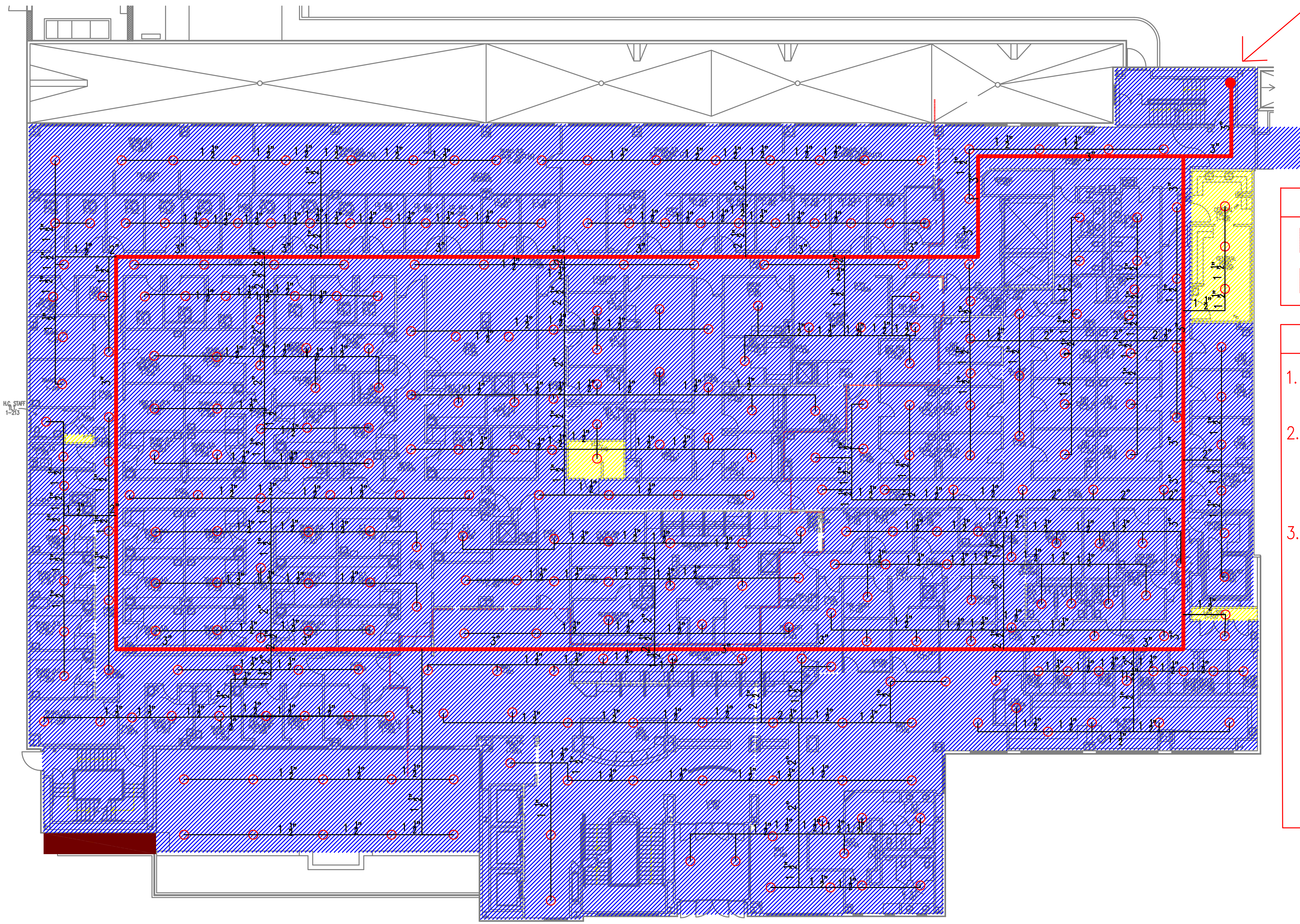


LEGEND	
(blue hatch)	LIGHT HAZARD
(yellow hatch)	ORDINARY HAZARD GROUP I

NOTES

1. SOLID RED LINES INDICATE THE LOCATION OF THE LOOPED MAIN.
2. SOLID BLACK LINES INDICATE BRANCH LINES AND ARMOVERS FEEDING INDIVIDUAL SPRINKLERS. PIPES FEEDING INDIVIDUAL SPRINKLERS THAT ARE NOT SHOWN ARE 1 1/4" IN DIAMETER.
3. THESE ARE PRELIMINARY SPRINKLER SYSTEM PLANS. CUT LENGTHS OF PIPE ARE NOT SHOWN. PIPE DIAMETERS ARE SLIGHTLY OVERSIZED TO BE CONSERVATIVE AND TO REDUCE SYSTEM DEMAND FOR THE PURPOSES OF AVOIDING THE NEED FOR A FIRE PUMP. IT MAY BE DECIDED PRIOR TO FINAL DESIGN AND INSTALLATION THAT SMALLER PIPE DIAMETERS WILL BE USED DUE TO CEILING SPACE LIMITATIONS, IN WHICH CASE HYDRAULIC CALCULATIONS WILL NEED TO BE PERFORMED TO ASSESS THE NEED TO INCLUDE A FIRE PUMP.

FIRST FLOOR



LEGEND	
(blue hatch)	LIGHT HAZARD
(yellow hatch)	ORDINARY HAZARD GROUP I

NOTES

1. SOLID RED LINES INDICATE THE LOCATION OF THE LOOPED MAIN.
2. SOLID BLACK LINES INDICATE BRANCH LINES AND ARMOVERS FEEDING INDIVIDUAL SPRINKLERS. PIPES FEEDING INDIVIDUAL SPRINKLERS THAT ARE NOT SHOWN ARE 1 1/4" IN DIAMETER.
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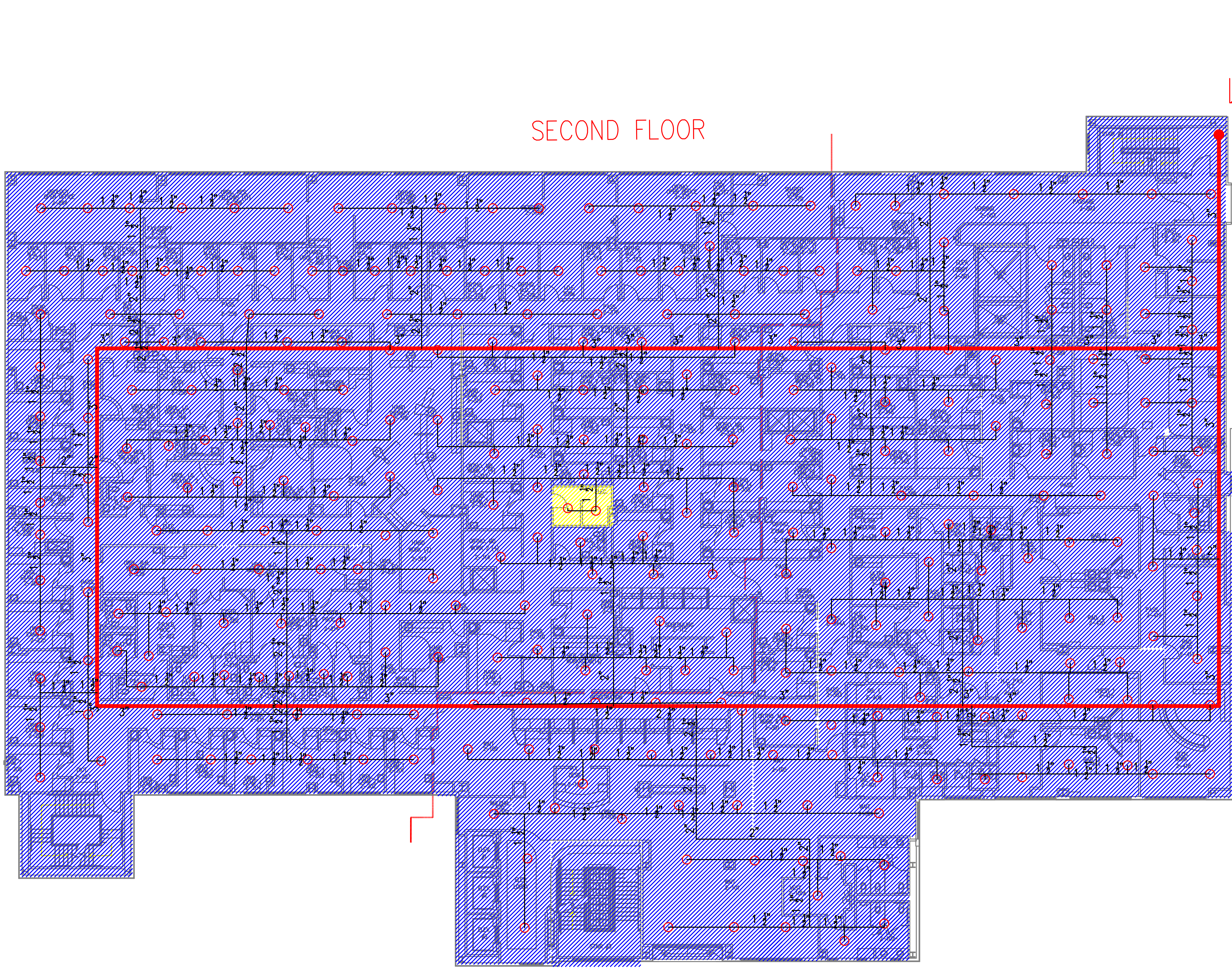


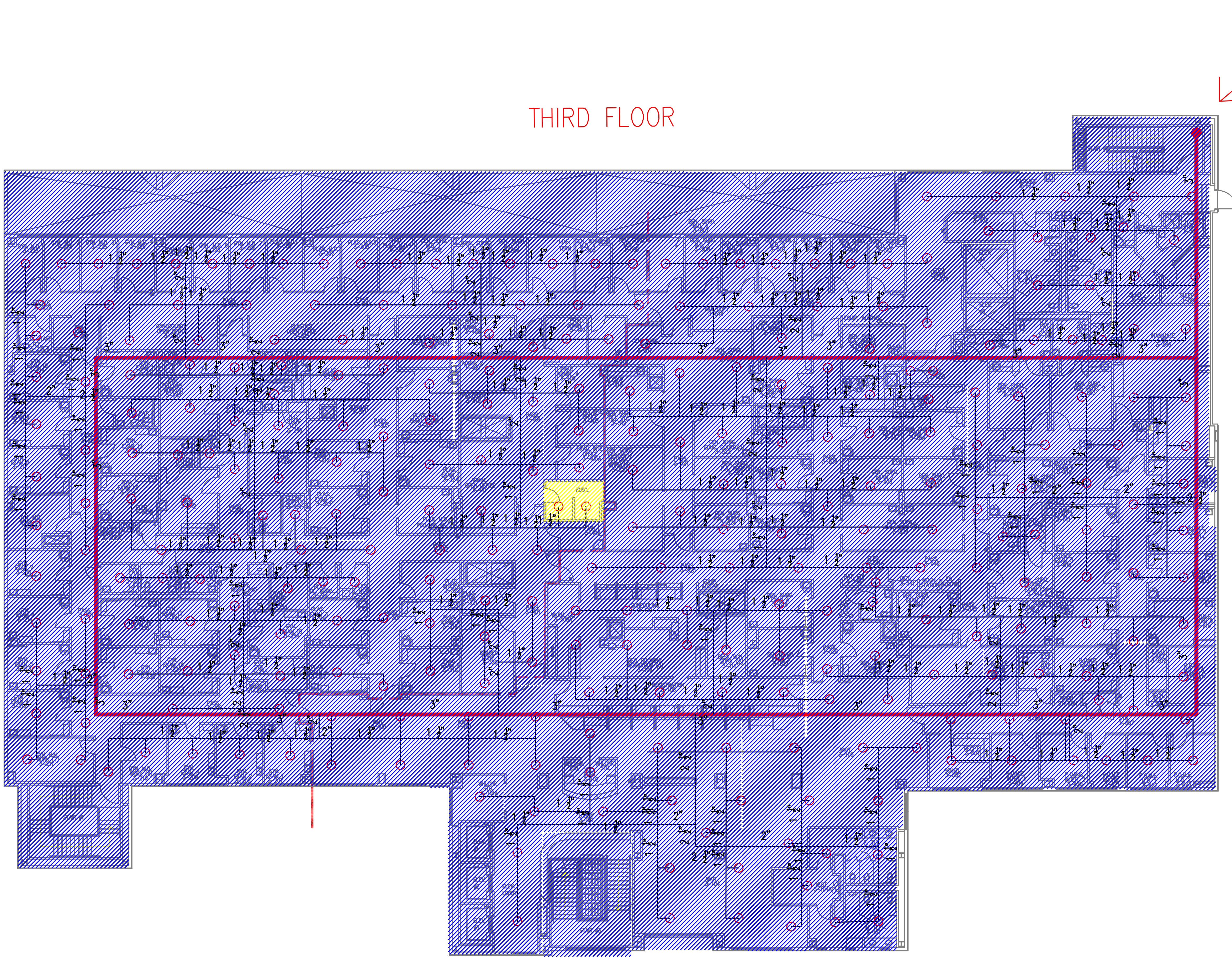
LEGEND

LIGHT HAZARD

ORDINARY HAZARD GROUP I

NOTES

1. SOLID RED LINES INDICATE THE LOCATION OF THE LOOPED MAIN.
2. SOLID BLACK LINES INDICATE BRANCH LINES AND ARMOVERS FEEDING INDIVIDUAL SPRINKLERS. PIPES FEEDING INDIVIDUAL SPRINKLERS THAT ARE NOT SHOWN ARE 1 1/4" IN DIAMETER.
3. THESE ARE PRELIMINARY SPRINKLER SYSTEM PLANS. CUT LENGTHS OF PIPE ARE NOT SHOWN. PIPE DIAMETERS ARE SLIGHTLY OVERSIZED TO BE CONSERVATIVE AND TO REDUCE SYSTEM DEMAND FOR THE PURPOSES OF AVOIDING THE NEED FOR A FIRE PUMP. IT MAY BE DECIDED PRIOR TO FINAL DESIGN AND INSTALLATION THAT SMALLER PIPE DIAMETERS WILL BE USED DUE TO CEILING SPACE LIMITATIONS, IN WHICH CASE HYDRAULIC CALCULATIONS WILL NEED TO BE PERFORMED TO ASSESS THE NEED TO INCLUDE A FIRE PUMP.



LEGEND

- LIGHT HAZARD
- ORDINARY HAZARD GROUP I

NOTES

1. SOLID RED LINES INDICATE THE LOCATION OF THE LOOPED MAIN.
2. SOLID BLACK LINES INDICATE BRANCH LINES AND ARMOVERS FEEDING INDIVIDUAL SPRINKLERS. PIPES FEEDING INDIVIDUAL SPRINKLERS THAT ARE NOT SHOWN ARE 1 1/4" IN DIAMETER.
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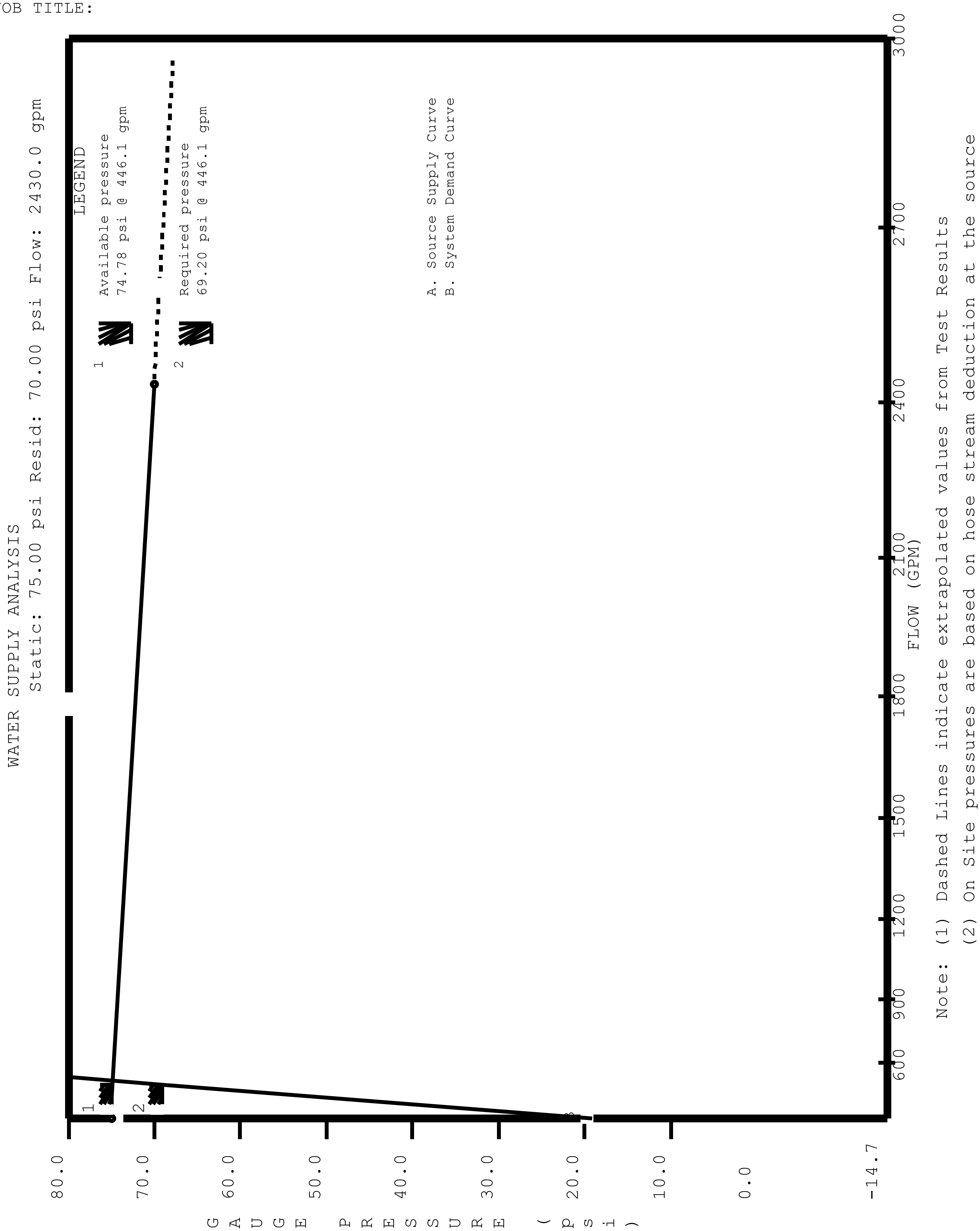
Appendix D

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_1.SDF
JOB TITLE:



DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_1.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0		2430.0	74.8		446.1	69.2

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	446.1 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	196.1 GPM

NODE ANALYSIS DATA

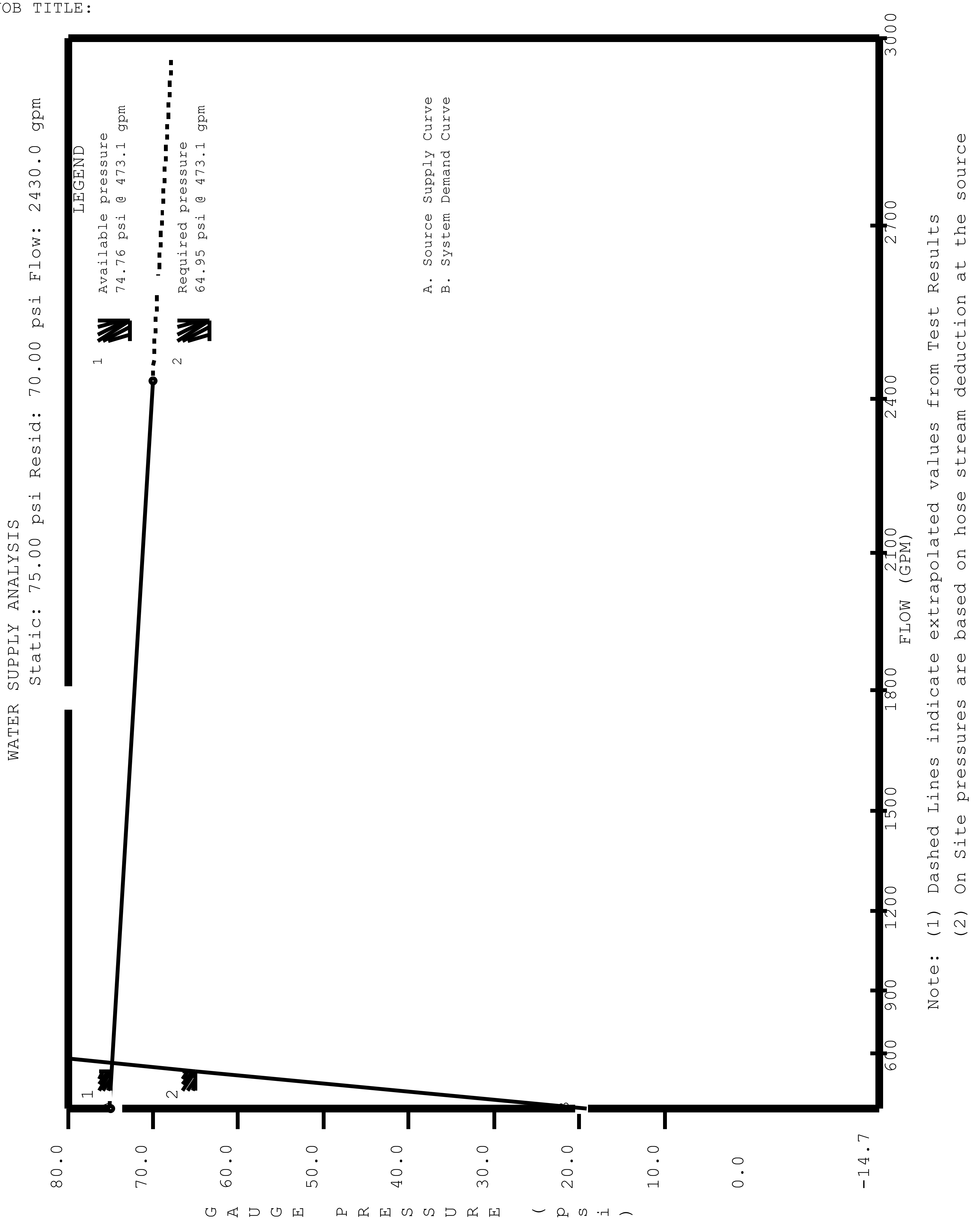
NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	69.2	446.1	
BOR	0.0	HOSE STREAM	65.0	250.0	
TOR	44.0	- - - -	44.7	- - -	
1	44.0	- - - -	42.0	- - -	
135	44.0	- - - -	37.8	- - -	
136	44.0	- - - -	37.6	- - -	
156	44.0	- - - -	38.4	- - -	
137	44.0	- - - -	25.5	- - -	
140	45.0	- - - -	20.5	- - -	
141	45.0	- - - -	19.4	- - -	
142	44.0	- - - -	23.8	- - -	
143	45.0	- - - -	22.8	- - -	
146	45.0	- - - -	18.1	- - -	
147	45.0	- - - -	16.3	- - -	
148	45.0	- - - -	15.5	- - -	
S159	41.0	K= 5.60	19.9	25.0	
S160	41.0	K= 5.60	20.3	25.2	
S161	41.0	K= 5.60	21.3	25.8	
S154	41.0	K= 5.60	23.5	27.2	
S155	41.0	K= 5.60	19.0	24.4	
S156	41.0	K= 5.60	17.2	23.2	
S157	41.0	K= 5.60	16.5	22.7	
S158	41.0	K= 5.60	16.1	22.5	

NFPA PIPE DATA

Pipe Tag Frm Node To Node	 El (ft) El (ft)	K-fac PT PT	Add Fl (q) Tot.(Q)	Fl To Node/ Disch	Vel Nom ID Act ID	Fit: Eq.Ln. (ft.)	L F T	C Pf/ft.	(Pt) (Pe) (Pf)	Notes
Pipe: 1		Source	250.0	Disch	5.0		300.00	120	4.2	
UNDGSRCE	-3.0	69.2	196.0	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	65.0	446.1		6.065	2G: 6.0	362.00	0.008	2.9	
Pipe: 2		0.0	0.0		4.9	E:10.0	47.00	120	20.4	
BOR	0.0	65.0	196.0	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	44.7	196.0		4.026	G: 2.0	103.00	0.013	1.3	
Pipe: 3		0.0	86.6	156	8.5		49.00	120	2.7	
TOR	44.0	44.7	109.5	135	3.000	E: 7.0	7.00		0.0	
1	44.0	42.0	196.0		3.068		56.00	0.048	2.7	
Pipe: 4		0.0	0.0		4.8		241.00	120	4.2	
1	44.0	42.0	109.5	136	3.000	T:15.0	15.00		0.0	
135	44.0	37.8	109.5		3.068		256.00	0.016	4.2	
Pipe: 5		0.0	196.0	137	4.8		8.50	120	0.3	
135	44.0	37.8	-86.6	156	3.000	E: 7.0	7.00		0.0	
136	44.0	37.6	109.5		3.068		15.50	0.016	0.3	
Pipe: 6		0.0	0.0		3.8		320.00	120	3.6	
1	44.0	42.0	86.6	136	3.000	E: 7.0	22.00		0.0	
156	44.0	38.4	86.6		3.068	T:15.0	342.00	0.011	3.6	
Pipe: 7		0.0	196.0	137	3.8		70.00	120	0.8	
156	44.0	38.4	-109.5	135	3.000	E: 7.0	7.00		0.0	
136	44.0	37.6	86.6		3.068		77.00	0.011	0.8	
Pipe: 8		0.0	120.0	142	30.9		3.00	120	12.1	
136	44.0	37.6	76.0	140	1.500	T: 8.0	8.00		0.0	
137	44.0	25.5	196.0		1.610		11.00	1.102	12.1	
Pipe: 9		0.0	25.8	S161	12.0		12.00	120	5.0	
137	44.0	25.5	50.2	141	1.500	E: 4.0	12.00		-0.4	
140	45.0	20.5	76.0		1.610	T: 8.0	24.00	0.191	4.6	
Pipe: 10		0.0	25.0	S159	7.9		11.50	120	1.0	
140	45.0	20.5	25.2	S160	1.500	----	0.00		0.0	
141	45.0	19.4	50.2		1.610		11.50	0.089	1.0	
Pipe: 11		0.0	92.9	146	11.5		13.00	120	1.7	
137	44.0	25.5	27.2	143	2.000	----	0.00		0.0	
142	44.0	23.8	120.0		2.067		13.00	0.132	1.7	
Pipe: 12		0.0	0.0		4.3		5.00	120	0.9	
142	44.0	23.8	27.2	S154	1.500	E: 4.0	12.00		-0.4	
143	45.0	22.8	27.2		1.610	T: 8.0	17.00	0.028	0.5	

Pipe Tag Frm Node To Node	 El (ft) El (ft)	K-fac PT PT	Add Fl (q) Tot.(Q)	Fl To Node/ Disch	Vel Nom ID Act ID	Fit: Eq.Ln. (ft.)	L F T	C Pf/ft.	(Pt) (Pe) (Pf)	Notes
Pipe: 13		0.0	24.4	S155	14.6		7.00	120	5.7	
142	44.0	23.8	68.5	147	1.500	E: 4.0	12.00		-0.4	
146	45.0	18.1	92.9		1.610	T: 8.0	19.00	0.277	5.3	
Pipe: 14		0.0	23.2	S156	10.8		11.50	120	1.8	
146	45.0	18.1	45.2	148	1.500	----	0.00		0.0	
147	45.0	16.3	68.5		1.610		11.50	0.157	1.8	
Pipe: 15		0.0	22.5	S158	7.1		10.75	120	0.8	
147	45.0	16.3	22.7	S157	1.500	----	0.00		0.0	
148	45.0	15.5	45.2		1.610		10.75	0.073	0.8	
Pipe: 16		5.60	25.8	Disch	5.5		5.00	120	0.8	
140	45.0	20.5	0.0		1.250	2E: 6.0	12.00		1.7	
S161	41.0	21.3	25.8		1.380	T: 6.0	17.00	0.055	0.9	
Pipe: 17		5.60	25.2	Disch	5.4		5.00	120	0.8	
141	45.0	19.4	0.0		1.250	2E: 6.0	12.00		1.7	
S160	41.0	20.3	25.2		1.380	T: 6.0	17.00	0.053	0.9	
Pipe: 18		5.60	25.0	Disch	5.4		15.50	120	0.5	
141	45.0	19.4	0.0		1.250	3E: 9.0	9.00		1.7	
S159	41.0	19.9	25.0		1.380		24.50	0.052	1.3	
Pipe: 19		5.60	27.2	Disch	5.8		5.00	120	0.7	
143	45.0	22.8	0.0		1.250	2E: 6.0	12.00		1.7	
S154	41.0	23.5	27.2		1.380	T: 6.0	17.00	0.060	1.0	
Pipe: 20		5.60	24.4	Disch	5.2		5.00	120	0.9	
146	45.0	18.1	0.0		1.250	2E: 6.0	12.00		1.7	
S155	41.0	19.0	24.4		1.380	T: 6.0	17.00	0.049	0.8	
Pipe: 21		5.60	23.2	Disch	5.0		5.00	120	1.0	
147	45.0	16.3	0.0		1.250	2E: 6.0	12.00		1.7	
S156	41.0	17.2	23.2		1.380	T: 6.0	17.00	0.045	0.8	
Pipe: 22		5.60	22.7	Disch	4.9		5.00	120	1.0	
148	45.0	15.5	0.0		1.250	2E: 6.0	12.00		1.7	
S157	41.0	16.5	22.7		1.380	T: 6.0	17.00	0.043	0.7	
Pipe: 23		5.60	22.5	Disch	4.8		16.00	120	0.7	
148	45.0	15.5	0.0		1.250	3E: 9.0	9.00		1.7	
S158	41.0	16.1	22.5		1.380		25.00	0.043	1.1	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_2.SDF
JOB TITLE:



DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_2.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0		2430.0	74.8		473.1	64.9

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	473.1 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	223.1 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	64.9	473.1	
BOR	0.0	HOSE STREAM	60.5	250.0	
TOR	44.0	- - - -	39.7	- - -	
1	44.0	- - - -	36.3	- - -	
156	44.0	- - - -	31.2	- - -	
174	44.0	- - - -	30.9	- - -	
157	44.0	- - - -	30.6	- - -	
158	44.0	- - - -	28.3	- - -	
159	44.0	- - - -	26.9	- - -	
160	45.0	- - - -	26.0	- - -	
164	44.0	- - - -	23.2	- - -	
165	45.0	- - - -	19.3	- - -	
166	45.0	- - - -	18.5	- - -	
167	45.0	- - - -	22.0	- - -	
169	44.0	- - - -	20.6	- - -	
170	45.0	- - - -	16.0	- - -	
171	45.0	- - - -	15.4	- - -	
172	45.0	- - - -	19.5	- - -	
S200	41.0	K= 5.60	26.5	28.8	
S192	41.0	K= 5.60	18.9	24.3	
S193	41.0	K= 5.60	19.3	24.6	
S194	41.0	K= 5.60	20.0	25.0	
S195	41.0	K= 5.60	22.8	26.7	
S186	41.0	K= 5.60	16.1	22.5	
S187	41.0	K= 5.60	16.4	22.7	
S188	41.0	K= 5.60	17.0	23.1	
S189	41.0	K= 5.60	20.4	25.3	

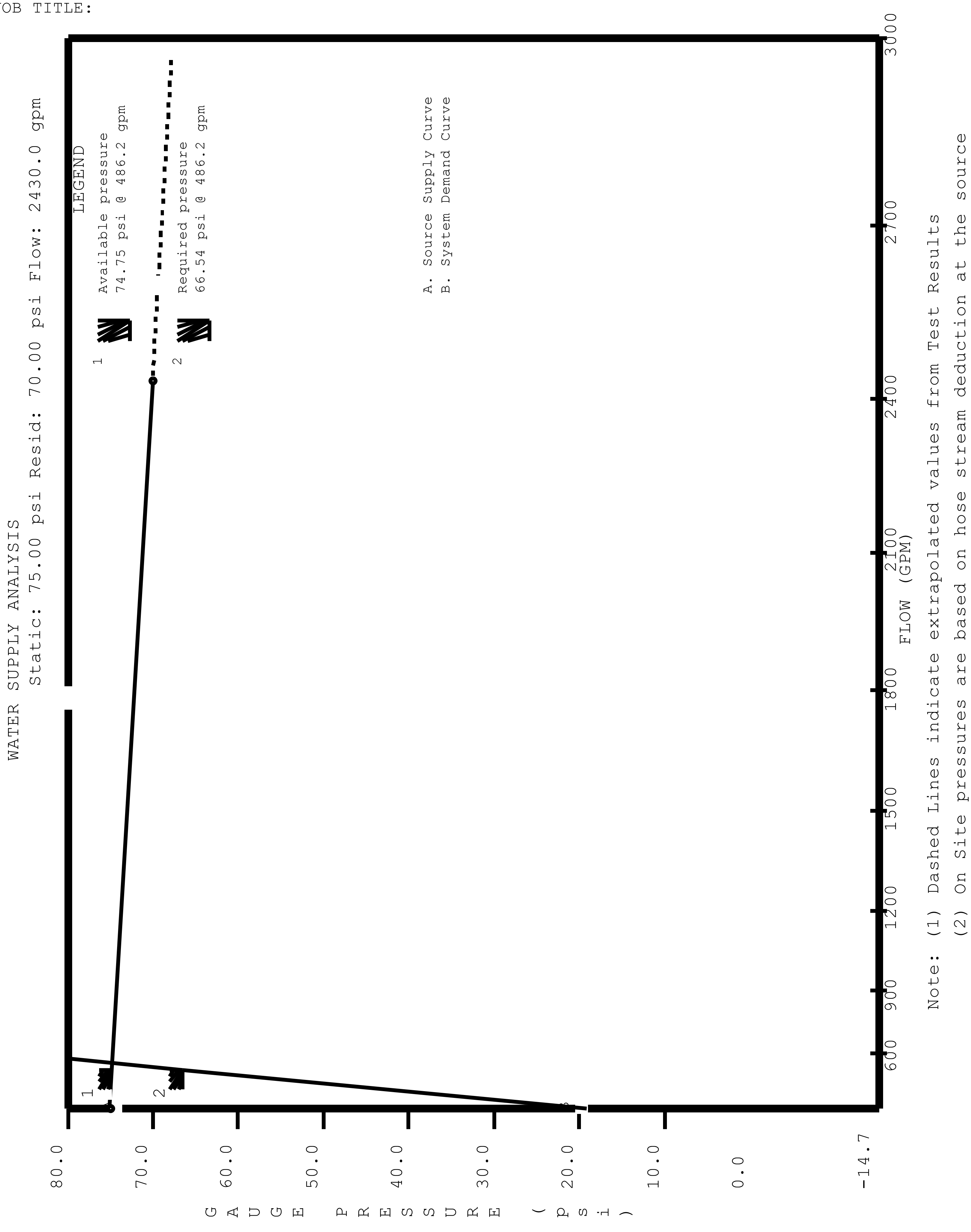
NFPA PIPE DATA

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		Source	250.0	Disch	5.3		300.00	120	4.5	
UNDGSRCE	-3.0	64.9	223.1	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	60.5	473.1		6.065	2G: 6.0	362.00	0.009	3.2	
Pipe: 2		0.0	0.0		5.6	E:10.0	47.00	120	20.7	
BOR	0.0	60.5	223.1	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	39.7	223.1		4.026	G: 2.0	103.00	0.016	1.7	
Pipe: 3		0.0	117.9	174	9.7		49.00	120	3.4	
TOR	44.0	39.7	105.2	156	3.000	E: 7.0	7.00		0.0	
1	44.0	36.3	223.1		3.068		56.00	0.061	3.4	
Pipe: 4		0.0	0.0		4.6		319.00	120	5.1	
1	44.0	36.3	105.2	157	3.000	E: 7.0	22.00		0.0	
156	44.0	31.2	105.2		3.068	T:15.0	341.00	0.015	5.1	
Pipe: 5		0.0	223.1	158	4.6		32.50	120	0.6	
156	44.0	31.2	-117.9	174	3.000	E: 7.0	7.00		0.0	
157	44.0	30.6	105.2		3.068		39.50	0.015	0.6	
Pipe: 6		0.0	0.0		5.1		270.00	120	5.4	
1	44.0	36.3	117.9	157	3.000	E: 7.0	22.00		0.0	
174	44.0	30.9	117.9		3.068	T:15.0	292.00	0.019	5.4	
Pipe: 7		0.0	223.1	158	5.1		16.50	120	0.3	
174	44.0	30.9	-105.2	156	3.000	----	0.00		0.0	
157	44.0	30.6	117.9		3.068		16.50	0.019	0.3	
Pipe: 8		0.0	0.0		14.9		1.50	120	2.4	
157	44.0	30.6	223.1	159	2.500	T:12.0	12.00		0.0	
158	44.0	28.3	223.1		2.469		13.50	0.174	2.4	
Pipe: 9		0.0	194.2	164	14.9		7.50	120	1.3	
158	44.0	28.3	28.8	160	2.500	----	0.00		0.0	
159	44.0	26.9	223.1		2.469		7.50	0.174	1.3	
Pipe: 10		0.0	0.0		4.5		3.00	120	0.9	
159	44.0	26.9	28.8	S200	1.500	E: 4.0	12.00		-0.4	
160	45.0	26.0	28.8		1.610	T: 8.0	15.00	0.032	0.5	
Pipe: 11		0.0	93.5	169	18.6		11.75	120	3.8	
159	44.0	26.9	74.0	165	2.000	----	0.00		0.0	
164	44.0	23.2	194.2		2.067		11.75	0.321	3.8	
Pipe: 12		0.0	25.0	S194	11.7		3.00	120	3.9	
164	44.0	23.2	48.9	166	1.500	2T:16.0	16.00		-0.4	
165	45.0	19.3	74.0		1.610		19.00	0.182	3.5	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_2.SDF
JOB TITLE:

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 12A		0.0	24.3	S192	7.7		9.75	120	0.8	
165	45.0	19.3	24.6	S193	1.500	----	0.00		0.0	
166	45.0	18.5	48.9		1.610		9.75	0.085	0.8	
Pipe: 13		0.0	0.0		4.2		9.00	120	1.1	
164	44.0	23.2	26.7	S195	1.500	2T:16.0	16.00		-0.4	
167	45.0	22.0	26.7		1.610		25.00	0.028	0.7	
Pipe: 14		0.0	25.3	172	14.7		9.25	120	2.6	
164	44.0	23.2	68.3	170	1.500	----	0.00		0.0	
169	44.0	20.6	93.5		1.610		9.25	0.280	2.6	
Pipe: 15		0.0	23.1	S188	10.8		10.50	120	4.6	
169	44.0	20.6	45.2	171	1.500	2T:16.0	16.00		-0.4	
170	45.0	16.0	68.3		1.610		26.50	0.156	4.1	
Pipe: 16		0.0	22.5	S186	7.1		8.25	120	0.6	
170	45.0	16.0	22.7	S187	1.500	----	0.00		0.0	
171	45.0	15.4	45.2		1.610		8.25	0.073	0.6	
Pipe: 17		0.0	0.0		4.0		10.75	120	1.1	
169	44.0	20.6	25.3	S189	1.500	2T:16.0	16.00		-0.4	
172	45.0	19.5	25.3		1.610		26.75	0.025	0.7	
Pipe: 18		5.60	28.8	Disch	6.2		9.25	120	0.5	
160	45.0	26.0	0.0		1.250	3E: 9.0	9.00		1.7	
S200	41.0	26.5	28.8		1.380		18.25	0.067	1.2	
Pipe: 19		5.60	25.0	Disch	5.4		8.25	120	0.7	
165	45.0	19.3	0.0		1.250	2E: 6.0	12.00		1.7	
S194	41.0	20.0	25.0		1.380	T: 6.0	20.25	0.052	1.0	
Pipe: 20		5.60	24.6	Disch	5.3		5.00	120	0.9	
166	45.0	18.5	0.0		1.250	2E: 6.0	12.00		1.7	
S193	41.0	19.3	24.6		1.380	T: 6.0	17.00	0.050	0.9	
Pipe: 21		5.60	24.3	Disch	5.2		18.25	120	0.4	
166	45.0	18.5	0.0		1.250	3E: 9.0	9.00		1.7	
S192	41.0	18.9	24.3		1.380		27.25	0.049	1.3	
Pipe: 22		5.60	26.7	Disch	5.7		8.00	120	0.7	
167	45.0	22.0	0.0		1.250	3E: 9.0	9.00		1.7	
S195	41.0	22.8	26.7		1.380		17.00	0.059	1.0	
Pipe: 23		5.60	23.1	Disch	4.9		5.00	120	1.0	
170	45.0	16.0	0.0		1.250	2E: 6.0	12.00		1.7	
S188	41.0	17.0	23.1		1.380	T: 6.0	17.00	0.045	0.8	
Pipe: 24		5.60	22.7	Disch	4.9		5.00	120	1.0	
171	45.0	15.4	0.0		1.250	2E: 6.0	12.00		1.7	
S187	41.0	16.4	22.7		1.380	T: 6.0	17.00	0.043	0.7	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_3.SDF
JOB TITLE:



DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_3.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0		2430.0	74.7		486.2	66.5

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	486.2 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	236.2 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	66.5	486.2	
BOR	0.0	HOSE STREAM	61.9	250.0	
TOR	44.0	- - - -	41.0	- - -	
1	44.0	- - - -	37.2	- - -	
124	44.0	- - - -	31.6	- - -	
98	44.0	- - - -	31.4	- - -	
104	44.0	- - - -	27.4	- - -	
109	44.0	- - - -	25.1	- - -	
113	45.0	- - - -	19.2	- - -	
114	45.0	- - - -	17.2	- - -	
115	45.0	- - - -	16.4	- - -	
116	44.0	- - - -	21.3	- - -	
117	45.0	- - - -	20.3	- - -	
120	45.0	- - - -	18.1	- - -	
121	45.0	- - - -	16.2	- - -	
122	45.0	- - - -	16.0	- - -	
123	45.0	- - - -	15.5	- - -	
S122	41.0	K= 5.60	19.8	24.9	
S123	41.0	K= 5.60	18.0	23.8	
S124	41.0	K= 5.60	17.2	23.2	
S125	41.0	K= 5.60	17.0	23.1	
S112	41.0	K= 5.60	21.2	25.8	
S113	41.0	K= 5.60	18.6	24.2	
S114	41.0	K= 5.60	16.9	23.0	
S115	41.0	K= 5.60	17.0	23.1	
S116	41.0	K= 5.60	16.1	22.5	
S117	41.0	K= 5.60	16.4	22.7	

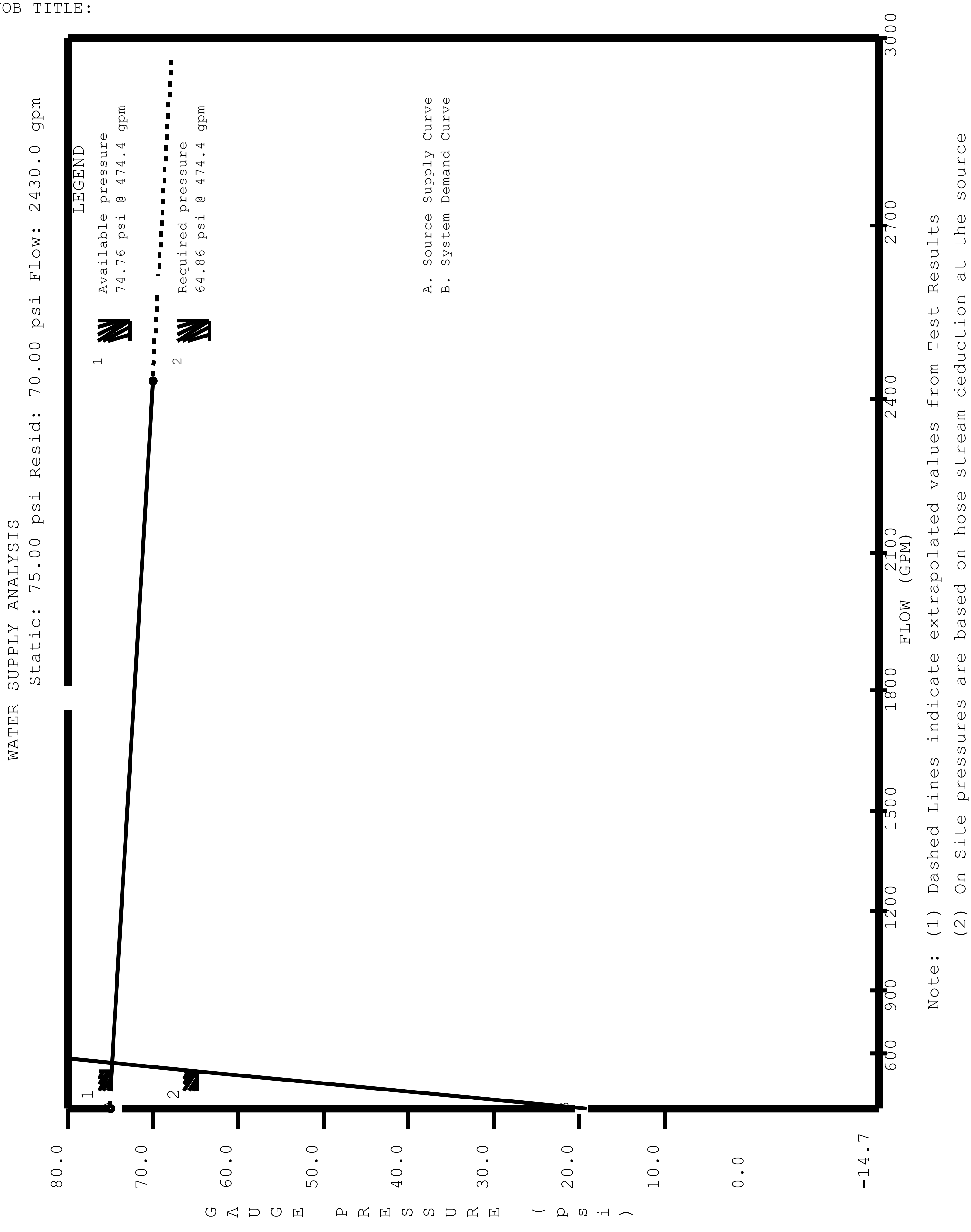
DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_3.SDF
JOB TITLE:

NFPA PIPE DATA

Pipe Tag Frm Node To Node	El (ft) El (ft)	K-fac PT PT	Add Fl (q) Tot.(Q)	Fl To Node/ Disch	Vel Nom ID Act ID	Fit: Eq.Ln. (ft.)	L F T	C Pf/ft.	(Pt) (Pe) (Pf)	Notes
Pipe: 1		Source	250.0	Disch	5.4		300.00	120	4.7	
UNDGSRCE	-3.0	66.5	236.1	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	61.9	486.2		6.065	2G: 6.0	362.00	0.009	3.4	
Pipe: 2		0.0	0.0		6.0	E:10.0	47.00	120	20.9	
BOR	0.0	61.9	236.1	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	41.0	236.1		4.026	G: 2.0	103.00	0.018	1.8	
Pipe: 3		0.0	94.4	124	10.2		49.00	120	3.8	
TOR	44.0	41.0	141.7	98	3.000	E: 7.0	7.00		0.0	
1	44.0	37.2	236.1		3.068		56.00	0.067	3.8	
Pipe: 4		0.0	236.1	104	6.1		206.00	120	5.8	
1	44.0	37.2	-94.4	124	3.000	T:15.0	15.00		0.0	
98	44.0	31.4	141.7		3.068		221.00	0.026	5.8	
Pipe: 5		0.0	0.0		4.1		417.00	120	5.6	
1	44.0	37.2	94.4	98	3.000	3E:21.0	36.00		0.0	
124	44.0	31.6	94.4		3.068	T:15.0	453.00	0.012	5.6	
Pipe: 6		0.0	236.1	104	4.1		15.25	120	0.2	
124	44.0	31.6	-141.7	1	3.000	----	0.00		0.0	
98	44.0	31.4	94.4		3.068		15.25	0.012	0.2	
Pipe: 7		0.0	0.0		15.8		9.00	120	4.1	
98	44.0	31.4	236.1	109	2.500	T:12.0	12.00		0.0	
104	44.0	27.4	236.1		2.469		21.00	0.194	4.1	
Pipe: 8		0.0	141.2	116	15.8		11.75	120	2.3	
104	44.0	27.4	95.0	113	2.500	----	0.00		0.0	
109	44.0	25.1	236.1		2.469		11.75	0.194	2.3	
Pipe: 9		0.0	24.9	S122	15.0		6.75	120	5.8	
109	44.0	25.1	70.0	114	1.500	E: 4.0	12.00		-0.4	
113	45.0	19.2	95.0		1.610	T: 8.0	18.75	0.288	5.4	
Pipe: 10		0.0	23.8	S123	11.0		12.75	120	2.1	
113	45.0	19.2	46.3	115	1.500	----	0.00		0.0	
114	45.0	17.2	70.0		1.610		12.75	0.164	2.1	
Pipe: 11		0.0	23.1	S125	7.3		10.25	120	0.8	
114	45.0	17.2	23.2	S124	1.500	----	0.00		0.0	
115	45.0	16.4	46.3		1.610		10.25	0.076	0.8	
Pipe: 12		0.0	115.4	120	13.5		21.25	120	3.8	
109	44.0	25.1	25.8	117	2.000	----	0.00		0.0	
116	44.0	21.3	141.2		2.067		21.25	0.178	3.8	

Pipe Tag / Frm Node / To Node	El (ft) / El (ft)	K-fac / PT / PT	Add Fl (q) / Tot.(Q)	Fl To Node/ Disch	Vel / Nom ID / Act ID	Fit: Eq.Ln. (ft.)	L / F / T	C / Pf/ft.	(Pt) / (Pe) / (Pf)	Notes
Pipe: 13		0.0	0.0		4.1		5.50	120	1.0	
116	44.0	21.3	25.8	S112	1.500	2T:16.0	16.00		-0.4	
117	45.0	20.3	25.8		1.610		21.50	0.026	0.6	
Pipe: 14		0.0	24.2	S113	11.0		2.75	120	3.2	
116	44.0	21.3	91.2	121	2.000	2T:20.0	20.00		-0.4	
120	45.0	18.1	115.4		2.067		22.75	0.122	2.8	
Pipe: 15		0.0	23.0	S114	14.4		7.00	120	1.9	
120	45.0	18.1	68.3	122	1.500	----	0.00		0.0	
121	45.0	16.2	91.2		1.610		7.00	0.268	1.9	
Pipe: 16		0.0	23.1	S115	10.8		1.25	120	0.2	
121	45.0	16.2	45.2	123	1.500	----	0.00		0.0	
122	45.0	16.0	68.3		1.610		1.25	0.156	0.2	
Pipe: 17		0.0	22.7	S117	7.1		7.75	120	0.6	
122	45.0	16.0	22.5	S116	1.500	----	0.00		0.0	
123	45.0	15.5	45.2		1.610		7.75	0.073	0.6	
Pipe: 18		5.60	24.9	Disch	5.3		10.50	120	0.6	
113	45.0	19.2	0.0		1.250	2E: 6.0	12.00		1.7	
S122	41.0	19.8	24.9		1.380	T: 6.0	22.50	0.051	1.2	
Pipe: 19		5.60	23.8	Disch	5.1		7.00	120	0.8	
114	45.0	17.2	0.0		1.250	2E: 6.0	12.00		1.7	
S123	41.0	18.0	23.8		1.380	T: 6.0	19.00	0.047	0.9	
Pipe: 20		5.60	23.2	Disch	5.0		9.00	120	0.8	
115	45.0	16.4	0.0		1.250	2E: 6.0	12.00		1.7	
S124	41.0	17.2	23.2		1.380	T: 6.0	21.00	0.045	0.9	
Pipe: 21		5.60	23.1	Disch	4.9		13.50	120	0.6	
115	45.0	16.4	0.0		1.250	2E: 6.0	12.00		1.7	
S125	41.0	17.0	23.1		1.380	T: 6.0	25.50	0.045	1.1	
Pipe: 22		5.60	25.8	Disch	5.5		7.50	120	0.8	
117	45.0	20.3	0.0		1.250	3E: 9.0	9.00		1.7	
S112	41.0	21.2	25.8		1.380		16.50	0.055	0.9	
Pipe: 23		5.60	24.2	Disch	5.2		12.50	120	0.5	
120	45.0	18.1	0.0		1.250	2E: 6.0	12.00		1.7	
S113	41.0	18.6	24.2		1.380	T: 6.0	24.50	0.049	1.2	
Pipe: 24		5.60	23.0	Disch	4.9		12.50	120	0.6	
121	45.0	16.2	0.0		1.250	2E: 6.0	12.00		1.7	
S114	41.0	16.9	23.0		1.380	T: 6.0	24.50	0.044	1.1	
Pipe: 25		5.60	23.1	Disch	5.0		5.00	120	1.0	
122	45.0	16.0	0.0		1.250	2E: 6.0	12.00		1.7	
S115	41.0	17.0	23.1		1.380	T: 6.0	17.00	0.045	0.8	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_4.SDF
JOB TITLE:



DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_4.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0		2430.0	74.8		474.4	64.9

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	474.4 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	224.4 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	64.9	474.4	
BOR	0.0	HOSE STREAM	60.4	250.0	
TOR	44.0	- - - -	39.6	- - -	
1	44.0	- - - -	36.2	- - -	
65	44.0	- - - -	31.6	- - -	
66	44.0	- - - -	28.2	- - -	
79	44.0	- - - -	31.7	- - -	
70	44.0	- - - -	25.4	- - -	
71	45.0	- - - -	24.4	- - -	
72	45.0	- - - -	22.5	- - -	
73	44.0	- - - -	22.9	- - -	
74	45.0	- - - -	20.5	- - -	
75	45.0	- - - -	20.4	- - -	
76	45.0	- - - -	16.4	- - -	
77	45.0	- - - -	16.0	- - -	
78	45.0	- - - -	15.3	- - -	
S78	41.0	K= 5.60	22.8	26.7	
S79	41.0	K= 5.60	23.2	27.0	
S80	41.0	K= 5.60	25.0	28.0	
S71	41.0	K= 5.60	16.2	22.5	
S72	41.0	K= 5.60	16.1	22.5	
S73	41.0	K= 5.60	16.8	22.9	
S74	41.0	K= 5.60	17.1	23.2	
S75	41.0	K= 5.60	21.1	25.7	
S76	41.0	K= 5.60	21.2	25.8	

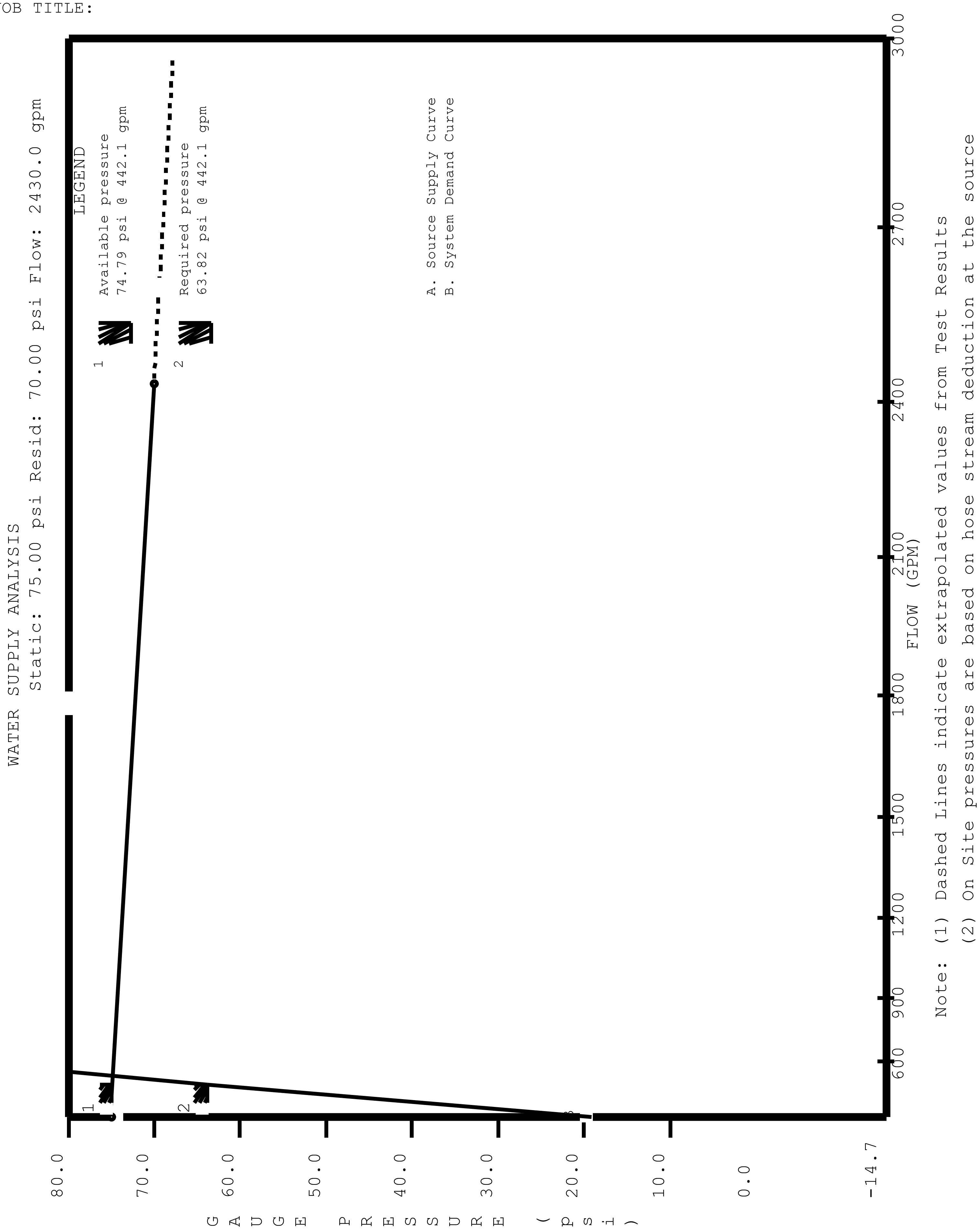
DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_4.SDF
JOB TITLE:

NFPA PIPE DATA

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		Source	250.0	Disch	5.3		300.00	120	4.5	
UNDGSRCE	-3.0	64.9	224.4	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	60.4	474.4		6.065	2G: 6.0	362.00	0.009	3.2	
Pipe: 2		0.0	0.0		5.7	E:10.0	47.00	120	20.7	
BOR	0.0	60.4	224.4	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	39.6	224.4		4.026	G: 2.0	103.00	0.016	1.7	
Pipe: 3		0.0	77.8	79	9.7		49.00	120	3.4	
TOR	44.0	39.6	146.6	65	3.000	E: 7.0	7.00		0.0	
1	44.0	36.2	224.4		3.068		56.00	0.061	3.4	
Pipe: 4		0.0	224.4	66	6.4		148.00	120	4.5	
1	44.0	36.2	-77.8	79	3.000	T:15.0	15.00		0.0	
65	44.0	31.6	146.6		3.068		163.00	0.028	4.5	
Pipe: 5		0.0	0.0		3.4		482.00	120	4.5	
1	44.0	36.2	77.8	65	3.000	3E:21.0	36.00		0.0	
79	44.0	31.7	77.8		3.068	T:15.0	518.00	0.009	4.5	
Pipe: 6		0.0	224.4	66	3.4		8.75	120	0.1	
79	44.0	31.7	-146.6	1	3.000	----	0.00		0.0	
65	44.0	31.6	77.8		3.068		8.75	0.009	0.1	
Pipe: 7		0.0	0.0		15.0		7.75	120	3.5	
65	44.0	31.6	224.4	70	2.500	T:12.0	12.00		0.0	
66	44.0	28.2	224.4		2.469		19.75	0.176	3.5	
Pipe: 8		0.0	142.6	73	15.0		15.50	120	2.7	
66	44.0	28.2	28.0	71	2.500	----	0.00		0.0	
70	44.0	25.4	224.4		2.469		15.50	0.176	2.7	
Pipe: 9		0.0	0.0		4.4		3.75	120	1.0	
70	44.0	25.4	28.0	S80	1.500	2T:16.0	16.00		-0.4	
71	45.0	24.4	28.0		1.610		19.75	0.030	0.6	
Pipe: 10		0.0	26.7	S78	8.5		8.75	120	2.9	
70	44.0	25.4	27.0	S79	1.500	2T:16.0	16.00		-0.4	
72	45.0	22.5	53.7		1.610		24.75	0.100	2.5	
Pipe: 11		0.0	91.2	76	13.6		14.00	120	2.5	
70	44.0	25.4	51.5	74	2.000	----	0.00		0.0	
73	44.0	22.9	142.6		2.067		14.00	0.181	2.5	
Pipe: 12		0.0	25.7	S75	8.1		4.75	120	2.4	
73	44.0	22.9	25.8	75	1.500	2T:16.0	16.00		-0.4	
74	45.0	20.5	51.5		1.610		20.75	0.093	1.9	

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 13		0.0	0.0		4.1		4.75	120	0.1	
74	45.0	20.5	25.8	S76	1.500	----	0.00		0.0	
75	45.0	20.4	25.8		1.610		4.75	0.026	0.1	
Pipe: 14		0.0	23.2	S74	14.4		6.75	120	6.5	
73	44.0	22.9	68.0	77	1.500	2T:16.0	16.00		-0.4	
76	45.0	16.4	91.2		1.610		22.75	0.267	6.1	
Pipe: 15		0.0	22.9	S73	10.7		2.50	120	0.4	
76	45.0	16.4	45.0	78	1.500	----	0.00		0.0	
77	45.0	16.0	68.0		1.610		2.50	0.155	0.4	
Pipe: 16		0.0	22.5	S72	7.1		9.00	120	0.7	
77	45.0	16.0	22.5	S71	1.500	----	0.00		0.0	
78	45.0	15.3	45.0		1.610		9.00	0.073	0.7	
Pipe: 17		5.60	28.0	Disch	6.0		5.00	120	0.6	
71	45.0	24.4	0.0		1.250	2E: 6.0	12.00		1.7	
S80	41.0	25.0	28.0		1.380	T: 6.0	17.00	0.064	1.1	
Pipe: 18		5.60	27.0	Disch	5.8		5.00	120	0.7	
72	45.0	22.5	0.0		1.250	2E: 6.0	12.00		1.7	
S79	41.0	23.2	27.0		1.380	T: 6.0	17.00	0.060	1.0	
Pipe: 19		5.60	26.7	Disch	5.7		16.25	120	0.3	
72	45.0	22.5	0.0		1.250	3E: 9.0	9.00		1.7	
S78	41.0	22.8	26.7		1.380		25.25	0.058	1.5	
Pipe: 20		5.60	22.5	Disch	4.8		11.25	120	0.9	
78	45.0	15.3	0.0		1.250	3E: 9.0	9.00		1.7	
S71	41.0	16.2	22.5		1.380		20.25	0.043	0.9	
Pipe: 21		5.60	22.5	Disch	4.8		9.75	120	0.8	
78	45.0	15.3	0.0		1.250	2E: 6.0	12.00		1.7	
S72	41.0	16.1	22.5		1.380	T: 6.0	21.75	0.043	0.9	
Pipe: 22		5.60	22.9	Disch	4.9		9.00	120	0.8	
77	45.0	16.0	0.0		1.250	2E: 6.0	12.00		1.7	
S73	41.0	16.8	22.9		1.380	T: 6.0	21.00	0.044	0.9	
Pipe: 23		5.60	23.2	Disch	5.0		9.75	120	0.8	
76	45.0	16.4	0.0		1.250	2E: 6.0	12.00		1.7	
S74	41.0	17.1	23.2		1.380	T: 6.0	21.75	0.045	1.0	
Pipe: 24		5.60	25.7	Disch	5.5		9.75	120	0.5	
74	45.0	20.5	0.0		1.250	2E: 6.0	12.00		1.7	
S75	41.0	21.1	25.7		1.380	T: 6.0	21.75	0.054	1.2	
Pipe: 25		5.60	25.8	Disch	5.5		9.00	120	0.7	
75	45.0	20.4	0.0		1.250	3E: 9.0	9.00		1.7	
S76	41.0	21.2	25.8		1.380		18.00	0.055	1.0	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_5.SDF
JOB TITLE:



DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_5.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0		2430.0	74.8		442.1	63.8

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	442.1 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	192.1 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	63.8	442.1	
BOR	0.0	HOSE STREAM	59.7	250.0	
TOR	44.0	- - - -	39.4	- - -	
1	44.0	- - - -	36.8	- - -	
174	44.0	- - - -	36.8	- - -	
184	44.0	- - - -	25.9	- - -	
185	44.0	- - - -	22.8	- - -	
186	45.0	- - - -	20.4	- - -	
187	44.0	- - - -	20.8	- - -	
188	44.0	- - - -	19.3	- - -	
189	45.0	- - - -	17.0	- - -	
190	44.0	- - - -	17.3	- - -	
191	45.0	- - - -	15.5	- - -	
S206	41.0	K= 5.60	17.7	23.6	
S207	41.0	K= 5.60	16.4	22.7	
S208	41.0	K= 5.60	16.1	22.5	
S209	41.0	K= 5.60	19.7	24.9	
S210	41.0	K= 5.60	17.9	23.7	
S211	41.0	K= 5.60	17.6	23.5	
S212	41.0	K= 5.60	20.6	25.4	
S213	41.0	K= 5.60	21.2	25.8	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_5.SDF
JOB TITLE:

NFPA PIPE DATA

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		Source	250.0	Disch	4.9		300.00	120	4.1	
UNDGSRCE	-3.0	63.8	192.1	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	59.7	442.1		6.065	2G: 6.0	362.00	0.008	2.8	
Pipe: 2		0.0	0.0		4.8	E:10.0	47.00	120	20.3	
BOR	0.0	59.7	192.1	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	39.4	192.1		4.026	G: 2.0	103.00	0.012	1.3	
Pipe: 3		0.0	0.0		8.3		49.00	120	2.6	
TOR	44.0	39.4	192.1	184	3.000	E: 7.0	7.00		0.0	
1	44.0	36.8	192.1		3.068		56.00	0.046	2.6	
Pipe: 4		0.0	0.0		0.0		368.00	120	0.0	
174	44.0	36.8	0.0		3.000	2E:14.0	29.00		0.0	
1	44.0	36.8	0.0		3.068	T:15.0	397.00	0.000	0.0	
Pipe: 5		0.0	0.0		8.3		231.00	120	10.9	
1	44.0	36.8	192.1	185	3.000	E: 7.0	7.00		0.0	
184	44.0	25.9	192.1		3.068		238.00	0.046	10.9	
Pipe: 6		0.0	140.9	187	12.9		11.50	120	3.1	
184	44.0	25.9	51.2	186	2.500	T:12.0	11.95		0.0	
185	44.0	22.8	192.1		2.467		23.45	0.133	3.1	
Pipe: 7		0.0	25.8	S213	8.1		8.75	120	2.3	
185	44.0	22.8	25.4	S212	1.500	E: 4.0	12.00		-0.4	
186	45.0	20.4	51.2		1.610	T: 8.0	20.75	0.092	1.9	
Pipe: 8		0.0	0.0		13.4		11.50	120	2.0	
185	44.0	22.8	140.9	188	2.000	----	0.00		0.0	
187	44.0	20.8	140.9		2.069		11.50	0.176	2.0	
Pipe: 9		0.0	24.9	S209	13.4		3.50	120	1.5	
187	44.0	20.8	47.2	189	2.000	E: 5.0	5.02		0.0	
188	44.0	19.3	140.9		2.069		8.52	0.176	1.5	
Pipe: 10		0.0	23.5	S211	7.4		7.00	120	2.3	
188	44.0	19.3	23.7	S210	1.500	2T:16.0	16.00		-0.4	
189	45.0	17.0	47.2		1.610		23.00	0.079	1.8	
Pipe: 11		0.0	23.6	S206	10.8		12.00	120	1.9	
188	44.0	19.3	45.2	191	1.500	----	0.00		0.0	
190	44.0	17.3	68.8		1.610		12.00	0.159	1.9	
Pipe: 12		0.0	22.5	S208	7.1		4.00	120	1.9	
190	44.0	17.3	22.7	S207	1.500	2T:16.0	16.00		-0.4	
191	45.0	15.5	45.2		1.610		20.00	0.073	1.5	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_5.SDF
JOB TITLE:

Pipe Tag Frm Node To Node	 El (ft) El (ft)	K-fac PT PT	Add Fl (q) Tot.(Q)	Fl To Node/ Disch	Vel Nom ID Act ID	Fit: Eq.Ln. (ft.)	L F T	C Pf/ft.	(Pt) (Pe) (Pf)	 Notes
Pipe: 13		5.60	23.6	Disch	5.1		11.50	120	0.4	
190	44.0	17.3	0.0		1.250	3E: 9.0	9.00		1.3	
S206	41.0	17.7	23.6		1.380		20.50	0.046	0.9	
Pipe: 14		5.60	22.7	Disch	4.9		5.00	120	1.0	
191	45.0	15.5	0.0		1.250	2E: 6.0	12.00		1.7	
S207	41.0	16.4	22.7		1.380	T: 6.0	17.00	0.043	0.7	
Pipe: 15		5.60	22.5	Disch	4.8		15.50	120	0.7	
191	45.0	15.5	0.0		1.250	3E: 9.0	9.00		1.7	
S208	41.0	16.1	22.5		1.380		24.50	0.043	1.0	
Pipe: 16		5.60	24.9	Disch	5.3		7.00	120	0.5	
188	44.0	19.3	0.0		1.250	3E: 9.0	9.00		1.3	
S209	41.0	19.7	24.9		1.380		16.00	0.051	0.8	
Pipe: 17		5.60	23.7	Disch	5.1		5.00	120	0.9	
189	45.0	17.0	0.0		1.250	2E: 6.0	12.00		1.7	
S210	41.0	17.9	23.7		1.380	T: 6.0	17.00	0.047	0.8	
Pipe: 18		5.60	23.5	Disch	5.0		15.25	120	0.6	
189	45.0	17.0	0.0		1.250	3E: 9.0	9.00		1.7	
S211	41.0	17.6	23.5		1.380		24.25	0.046	1.1	
Pipe: 19		5.60	25.4	Disch	5.4		18.50	120	0.1	
186	45.0	20.4	0.0		1.250	4E:12.0	12.00		1.7	
S212	41.0	20.6	25.4		1.380		30.50	0.053	1.6	
Pipe: 20		5.60	25.8	Disch	5.5		5.00	120	0.8	
186	45.0	20.4	0.0		1.250	2E: 6.0	12.00		1.7	
S213	41.0	21.2	25.8		1.380	T: 6.0	17.00	0.055	0.9	

NOTES (HASS):

(1) Calculations were performed by the HASS 8.5 computer program
under license no. 2707032950 granted by
HRS Systems, Inc.
208 Southside Square
Petersburg, TN 37144
(931) 659-9760

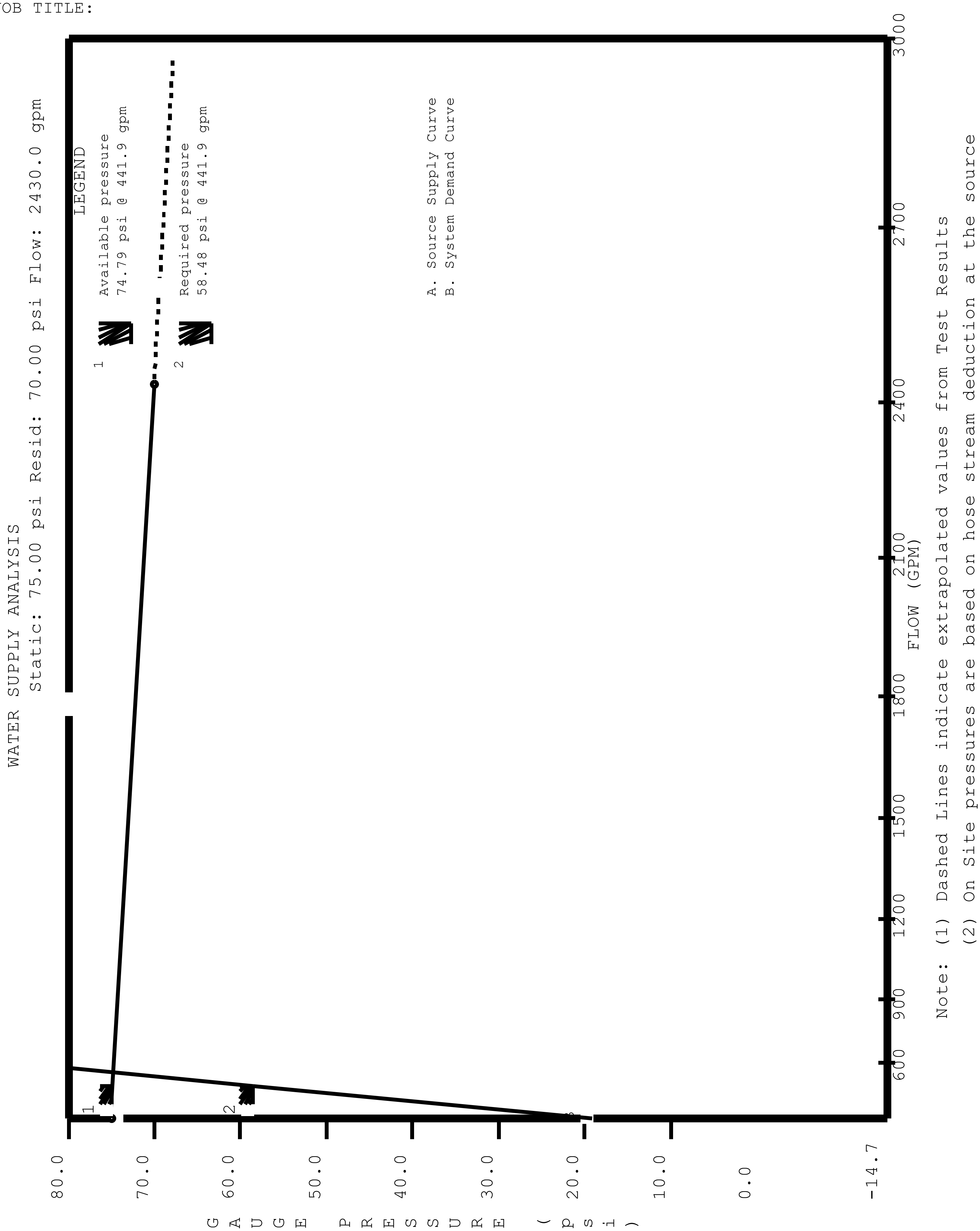
(2) The system has been calculated to provide an average
imbalance at each node of 0.003 gpm and a maximum
imbalance at any node of 0.055 gpm.

(3) Total pressure at each node is used in balancing the system.
Maximum water velocity is 13.4 ft/sec at pipe 9.

(4) Items listed in bold print on the cover sheet

are automatically transferred from the calculation report.

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_6.SDF
JOB TITLE:



DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_6.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI) @	FLOW (GPM)	AVAIL. PRESS. (PSI) @	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0	2430.0	74.8	441.9	58.5

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	441.9 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	191.9 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	58.5	441.9	
BOR	0.0	HOSE STREAM	54.4	250.0	
TOR	44.0	- - - -	34.1	- - -	
1	44.0	- - - -	31.5	- - -	
65	44.0	- - - -	29.1	- - -	
40	44.0	- - - -	28.8	- - -	
49	44.0	- - - -	23.4	- - -	
55	44.0	- - - -	22.0	- - -	
60	44.0	- - - -	20.5	- - -	
50	45.0	- - - -	20.9	- - -	
51	45.0	- - - -	20.6	- - -	
56	45.0	- - - -	17.7	- - -	
57	45.0	- - - -	17.0	- - -	
61	45.0	- - - -	16.7	- - -	
62	45.0	- - - -	15.6	- - -	
S56	41.0	K= 5.60	21.0	25.7	
S57	41.0	K= 5.60	21.6	26.0	
S51	41.0	K= 5.60	18.7	24.2	
S50	41.0	K= 5.60	17.8	23.6	
S49	41.0	K= 5.60	17.6	23.5	
S43	41.0	K= 5.60	16.1	22.5	
S44	41.0	K= 5.60	16.6	22.8	
S45	41.0	K= 5.60	17.7	23.6	

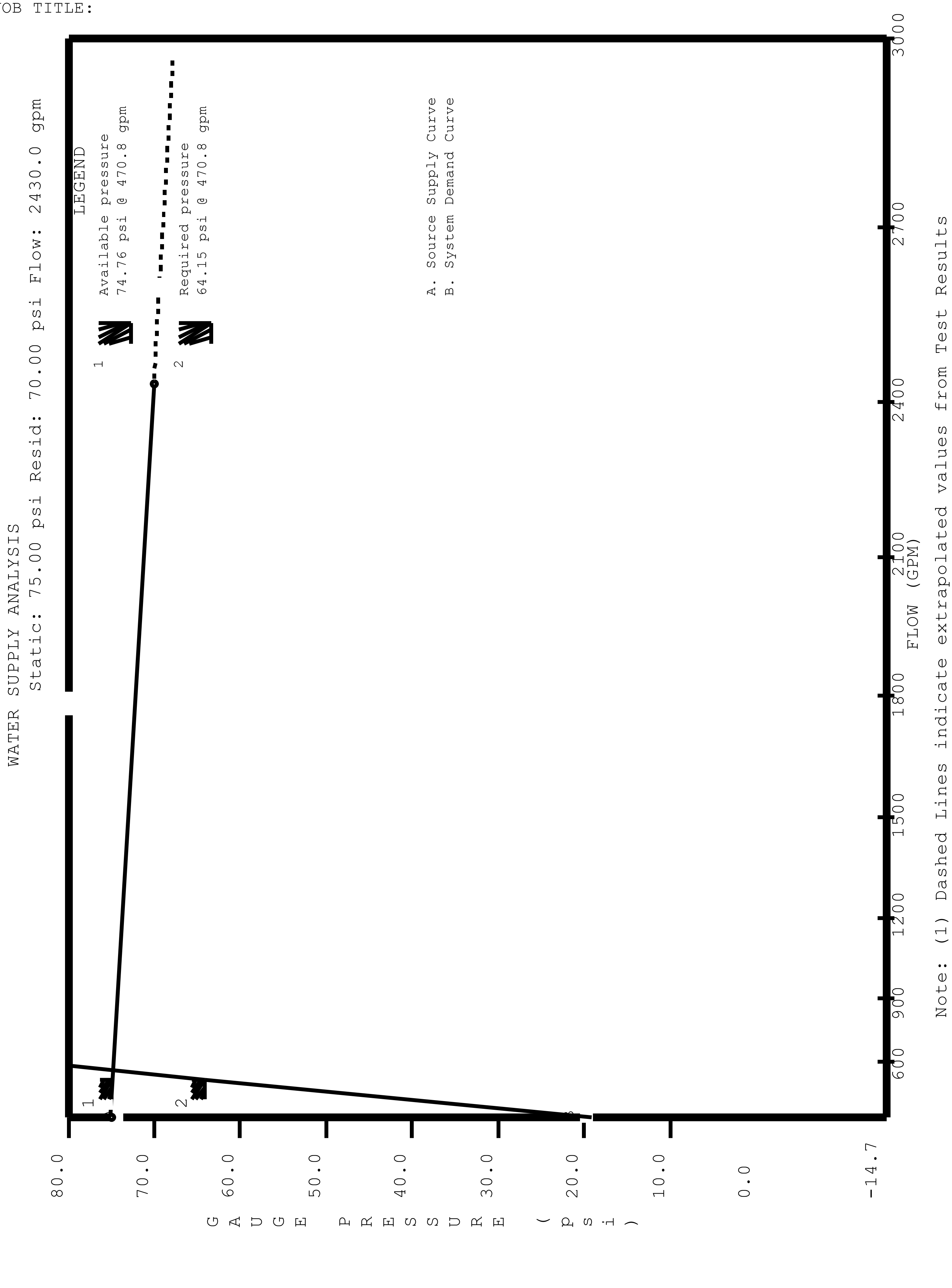
NFPA PIPE DATA

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		Source	250.0	Disch	4.9		300.00	120	4.1	
UNDGSRCE	-3.0	58.5	191.9	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	54.4	441.9		6.065	2G: 6.0	362.00	0.008	2.8	
Pipe: 2		0.0	0.0		4.8	E:10.0	47.00	120	20.3	
BOR	0.0	54.4	191.9	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	34.1	191.9		4.026	G: 2.0	103.00	0.012	1.3	
Pipe: 3		0.0	135.9	40	8.3		49.00	120	2.6	
TOR	44.0	34.1	56.0	65	3.000	E: 7.0	7.00		0.0	
1	44.0	31.5	191.9		3.068		56.00	0.046	2.6	
Pipe: 4		0.0	0.0		2.4		491.00	120	2.4	
1	44.0	31.5	56.0	40	3.000	3E:21.0	21.00		0.0	
65	44.0	29.1	56.0		3.068		512.00	0.005	2.4	
Pipe: 5		0.0	191.9	49	2.4		54.00	120	0.3	
65	44.0	29.1	-135.9	1	3.000	----	0.00		0.0	
40	44.0	28.8	56.0		3.068		54.00	0.005	0.3	
Pipe: 6		0.0	191.9	49	5.9		95.00	120	2.7	
1	44.0	31.5	-56.0	65	3.000	T:15.0	15.00		0.0	
40	44.0	28.8	135.9		3.068		110.00	0.024	2.7	
Pipe: 7		0.0	140.2	55	12.9		29.00	120	5.4	
40	44.0	28.8	51.7	50	2.500	T:12.0	11.95		0.0	
49	44.0	23.4	191.9		2.467		40.95	0.133	5.4	
Pipe: 8		0.0	26.0	S57	8.1		10.25	120	2.5	
49	44.0	23.4	25.7	51	1.500	E: 4.0	12.00		-0.4	
50	45.0	20.9	51.7		1.610	T: 8.0	22.25	0.094	2.1	
Pipe: 9		0.0	0.0		4.0		9.50	120	0.2	
50	45.0	20.9	25.7	S56	1.500	----	0.00		0.0	
51	45.0	20.6	25.7		1.610		9.50	0.026	0.2	
Pipe: 10		0.0	68.9	60	13.4		8.25	120	1.4	
49	44.0	23.4	71.3	56	2.000	----	0.00		0.0	
55	44.0	22.0	140.2		2.069		8.25	0.175	1.4	
Pipe: 11		0.0	24.2	S51	11.2		10.25	120	4.2	
55	44.0	22.0	47.1	57	1.500	E: 4.0	12.00		-0.4	
56	45.0	17.7	71.3		1.610	T: 8.0	22.25	0.170	3.8	
Pipe: 12		0.0	23.6	S50	7.4		9.50	120	0.7	
56	45.0	17.7	23.5	S49	1.500	----	0.00		0.0	
57	45.0	17.0	47.1		1.610		9.50	0.079	0.7	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_6.SDF
JOB TITLE:

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 13		0.0	0.0		10.9		9.00	120	1.4	
55	44.0	22.0	68.9	61	1.500	----	0.00		0.0	
60	44.0	20.5	68.9		1.610		9.00	0.159	1.4	
Pipe: 14		0.0	23.6	S45	10.9		9.00	120	3.8	
60	44.0	20.5	45.3	62	1.500	E: 4.0	12.00		-0.4	
61	45.0	16.7	68.9		1.610	T: 8.0	21.00	0.159	3.3	
Pipe: 15		0.0	22.8	S44	7.1		15.00	120	1.1	
61	45.0	16.7	22.5	S43	1.500	----	0.00		0.0	
62	45.0	15.6	45.3		1.610		15.00	0.073	1.1	
Pipe: 16		5.60	22.5	Disch	4.8		20.00	120	0.5	
62	45.0	15.6	0.0		1.250	3E: 9.0	9.00		1.7	
S43	41.0	16.1	22.5		1.380		29.00	0.043	1.2	
Pipe: 17		5.60	22.8	Disch	4.9		5.00	120	1.0	
62	45.0	15.6	0.0		1.250	2E: 6.0	12.00		1.7	
S44	41.0	16.6	22.8		1.380	T: 6.0	17.00	0.044	0.7	
Pipe: 18		5.60	23.6	Disch	5.1		5.00	120	0.9	
61	45.0	16.7	0.0		1.250	2E: 6.0	12.00		1.7	
S45	41.0	17.7	23.6		1.380	T: 6.0	17.00	0.046	0.8	
Pipe: 19		5.60	23.5	Disch	5.0		15.50	120	0.6	
57	45.0	17.0	0.0		1.250	3E: 9.0	9.00		1.7	
S49	41.0	17.6	23.5		1.380		24.50	0.046	1.1	
Pipe: 20		5.60	23.6	Disch	5.1		8.50	120	0.8	
57	45.0	17.0	0.0		1.250	2E: 6.0	12.00		1.7	
S50	41.0	17.8	23.6		1.380	T: 6.0	20.50	0.047	1.0	
Pipe: 21		5.60	24.2	Disch	5.2		5.00	120	0.9	
56	45.0	17.7	0.0		1.250	2E: 6.0	12.00		1.7	
S51	41.0	18.7	24.2		1.380	T: 6.0	17.00	0.049	0.8	
Pipe: 22		5.60	25.7	Disch	5.5		15.50	120	0.4	
51	45.0	20.6	0.0		1.250	3E: 9.0	9.00		1.7	
S56	41.0	21.0	25.7		1.380		24.50	0.054	1.3	
Pipe: 23		5.60	26.0	Disch	5.6		6.25	120	0.7	
50	45.0	20.9	0.0		1.250	2E: 6.0	12.00		1.7	
S57	41.0	21.6	26.0		1.380	T: 6.0	18.25	0.056	1.0	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_7.SDF
JOB TITLE:



Note: (1) Dashed Lines indicate extrapolated values from Test Results
(2) On Site pressures are based on hose stream deduction at the source

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_7.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI) @	FLOW (GPM)	AVAIL. PRESS. (PSI) @	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0	2430.0	74.8	470.8	64.2

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	470.8 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	220.8 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	64.2	470.8	
BOR	0.0	HOSE STREAM	59.7	250.0	
TOR	44.0	- - - -	39.0	- - -	
1	44.0	- - - -	35.7	- - -	
192	44.0	- - - -	31.0	- - -	
217	44.0	- - - -	31.0	- - -	
218	44.0	- - - -	25.6	- - -	
222	45.0	- - - -	22.0	- - -	
223	45.0	- - - -	20.8	- - -	
224	44.0	- - - -	22.0	- - -	
225	45.0	- - - -	19.9	- - -	
227	45.0	- - - -	17.4	- - -	
228	45.0	- - - -	15.6	- - -	
S243	41.0	K= 5.60	20.7	25.5	
S244	41.0	K= 5.60	20.4	25.3	
S245	41.0	K= 5.60	17.9	23.7	
S246	41.0	K= 5.60	16.5	22.7	
S247	41.0	K= 5.60	16.1	22.5	
S248	41.0	K= 5.60	16.2	22.6	
S253	41.0	K= 5.60	22.7	26.7	
S254	41.0	K= 5.60	21.5	26.0	
S255	41.0	K= 5.60	21.2	25.8	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_7.SDF
JOB TITLE:

NFPA PIPE DATA

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		Source	250.0	Disch	5.2		300.00	120	4.5	
UNDGSRCE	-3.0	64.2	220.7	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	59.7	470.8		6.065	2G: 6.0	362.00	0.009	3.2	
Pipe: 2		0.0	0.0		5.6	E:10.0	47.00	120	20.7	
BOR	0.0	59.7	220.7	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	39.0	220.7		4.026	G: 2.0	103.00	0.016	1.6	
Pipe: 3		0.0	137.5	217	9.6		49.00	120	3.3	
TOR	44.0	39.0	83.2	192	3.000	E: 7.0	7.00		0.0	
1	44.0	35.7	220.7		3.068		56.00	0.059	3.3	
Pipe: 4		0.0	0.0		3.6		451.00	120	4.7	
1	44.0	35.7	83.2	217	3.000	2E:14.0	29.00		0.0	
192	44.0	31.0	83.2		3.068	T:15.0	480.00	0.010	4.7	
Pipe: 5		0.0	220.7	218	6.0		184.00	120	4.7	
1	44.0	35.7	-83.2	192	3.000	E: 7.0	7.00		0.0	
217	44.0	31.0	137.5		3.068		191.00	0.025	4.7	
Pipe: 6		0.0	220.7	218	3.6		4.00	120	0.0	
192	44.0	31.0	-137.5	1	3.000	----	0.00		0.0	
217	44.0	31.0	83.2		3.068		4.00	0.010	0.0	
Pipe: 7		0.0	142.3	224	21.1		3.25	120	5.4	
217	44.0	31.0	78.4	222	2.000	T:10.0	10.00		0.0	
218	44.0	25.6	220.7		2.067		13.25	0.406	5.4	
Pipe: 8		0.0	26.7	S253	12.4		3.25	120	3.5	
218	44.0	25.6	51.7	223	1.500	E: 4.0	12.00		-0.4	
222	45.0	22.0	78.4		1.610	T: 8.0	15.25	0.202	3.1	
Pipe: 9		0.0	25.8	S255	8.2		13.50	120	1.3	
222	45.0	22.0	26.0	S254	1.500	----	0.00		0.0	
223	45.0	20.8	51.7		1.610		13.50	0.094	1.3	
Pipe: 10		0.0	91.5	227	13.6		19.50	120	3.5	
218	44.0	25.6	50.8	225	2.000	----	0.00		0.0	
224	44.0	22.0	142.3		2.067		19.50	0.180	3.5	
Pipe: 11		0.0	25.3	S244	8.0		6.75	120	2.1	
224	44.0	22.0	25.5	S243	1.500	E: 4.0	12.00		-0.4	
225	45.0	19.9	50.8		1.610	T: 8.0	18.75	0.091	1.7	
Pipe: 12		0.0	23.7	S245	14.4		3.75	120	4.7	
224	44.0	22.0	67.8	228	1.500	E: 4.0	12.00		-0.4	
227	45.0	17.4	91.5		1.610	T: 8.0	15.75	0.269	4.2	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_7.SDF
JOB TITLE:

Pipe Tag / Frm Node / To Node	El (ft) / El (ft)	K-fac / PT / PT	Add Fl (q) / Tot.(Q)	Fl To / Node/ / Disch	Vel / Nom ID / Act ID	Fit: / Eq.Ln. / (ft.)	L / F / T	C / / Pf/ft.	(Pt) / (Pe) / (Pf)	Notes
Pipe: 13		0.0	22.6	S248	10.7		11.75	120	1.8	
227	45.0	17.4	22.7	S246	1.500	----	0.00		0.0	
228	45.0	15.6	67.8		1.610		11.75	0.155	1.8	
Pipe: 14		5.60	25.5	Disch	5.5		5.00	120	0.8	
225	45.0	19.9	0.0		1.250	2E: 6.0	12.00		1.7	
S243	41.0	20.7	25.5		1.380	T: 6.0	17.00	0.054	0.9	
Pipe: 15		5.60	25.3	Disch	5.4		12.50	120	0.4	
225	45.0	19.9	0.0		1.250	2E: 6.0	12.00		1.7	
S244	41.0	20.4	25.3		1.380	T: 6.0	24.50	0.053	1.3	
Pipe: 16		5.60	23.7	Disch	5.1		13.50	120	0.5	
227	45.0	17.4	0.0		1.250	2E: 6.0	12.00		1.7	
S245	41.0	17.9	23.7		1.380	T: 6.0	25.50	0.047	1.2	
Pipe: 17		5.60	22.7	Disch	4.9		6.50	120	0.9	
228	45.0	15.6	0.0		1.250	2E: 6.0	12.00		1.7	
S246	41.0	16.5	22.7		1.380	T: 6.0	18.50	0.043	0.8	
Pipe: 18		5.60	22.5	Disch	4.8		15.00	120	0.6	
228	45.0	15.6	0.0		1.250	2E: 6.0	12.00		1.7	
S247	41.0	16.1	22.5		1.380	T: 6.0	27.00	0.043	1.1	
Pipe: 19		5.60	22.6	Disch	4.8		15.50	120	0.7	
228	45.0	15.6	0.0		1.250	3E: 9.0	9.00		1.7	
S248	41.0	16.2	22.6		1.380		24.50	0.043	1.0	
Pipe: 20		5.60	26.7	Disch	5.7		6.50	120	0.7	
222	45.0	22.0	0.0		1.250	2E: 6.0	12.00		1.7	
S253	41.0	22.7	26.7		1.380	T: 6.0	18.50	0.058	1.1	
Pipe: 21		5.60	26.0	Disch	5.6		6.50	120	0.7	
223	45.0	20.8	0.0		1.250	2E: 6.0	12.00		1.7	
S254	41.0	21.5	26.0		1.380	T: 6.0	18.50	0.055	1.0	
Pipe: 22		5.60	25.8	Disch	5.5		15.00	120	0.4	
223	45.0	20.8	0.0		1.250	3E: 9.0	9.00		1.7	
S255	41.0	21.2	25.8		1.380		24.00	0.055	1.3	

NOTES (HASS):

(1) Calculations were performed by the HASS 8.5 computer program
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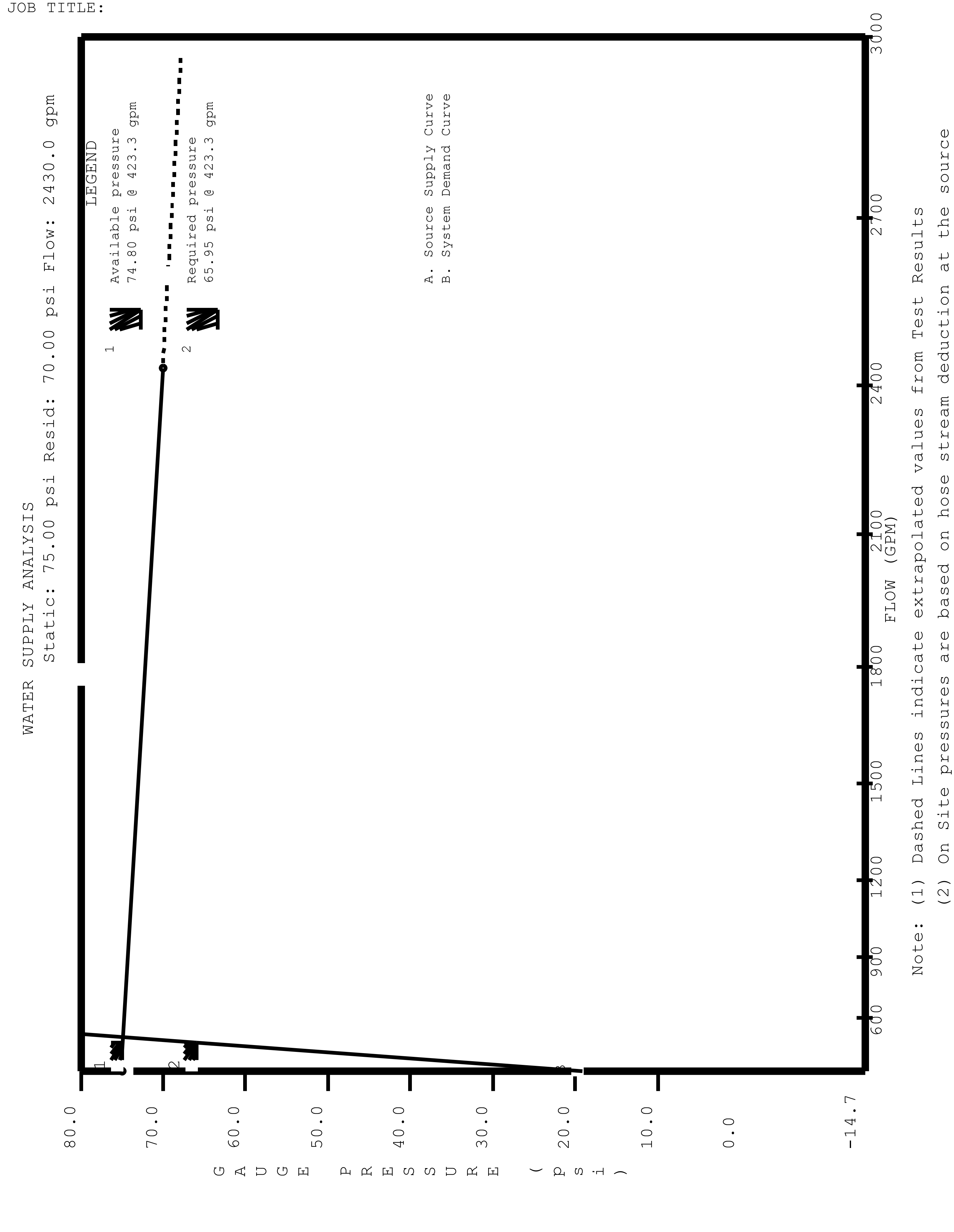
HRS Systems, Inc.
208 Southside Square
Petersburg, TN 37144
(931) 659-9760

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_8.SDF
JOB TITLE:



NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0		2430.0	74.8		423.3	65.9

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	423.3 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	173.3 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	65.9	423.3	
BOR	0.0	HOSE STREAM	62.1	250.0	
TOR	44.0	- - - -	41.9	- - -	
1	44.0	- - - -	39.8	- - -	
157	44.0	- - - -	36.5	- - -	
174	44.0	- - - -	36.4	- - -	
175	45.0	- - - -	32.0	- - -	
180	45.0	- - - -	29.7	- - -	
181	45.0	- - - -	20.5	- - -	
182	45.0	- - - -	16.5	- - -	
183	45.0	- - - -	15.4	- - -	
S179	41.0	K= 5.60	29.7	30.5	
S180	41.0	K= 5.60	21.0	25.7	
S181	41.0	K= 5.60	21.0	25.6	
S182	41.0	K= 5.60	17.2	23.2	
S183	41.0	K= 5.60	17.2	23.2	
S184	41.0	K= 5.60	16.2	22.5	
S185	41.0	K= 5.60	16.1	22.5	

NFPA PIPE DATA

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		Source	250.0	Disch	4.7		300.00	120	3.9	
UNDGSRCE	-3.0	65.9	173.3	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	62.1	423.3		6.065	2G: 6.0	362.00	0.007	2.6	
Pipe: 2		0.0	0.0		4.4	E:10.0	47.00	120	20.1	
BOR	0.0	62.1	173.3	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	41.9	173.3		4.026	G: 2.0	103.00	0.010	1.0	
Pipe: 3		0.0	95.0	174	7.5		49.00	120	2.1	
TOR	44.0	41.9	78.3	157	3.000	E: 7.0	7.00		0.0	
1	44.0	39.8	173.3		3.068		56.00	0.038	2.1	
Pipe: 4		0.0	0.0		3.4		352.00	120	3.3	
1	44.0	39.8	78.3	174	3.000	2E:14.0	29.00		0.0	
157	44.0	36.5	78.3		3.068	T:15.0	381.00	0.009	3.3	
Pipe: 5		0.0	173.3	175	3.4		16.50	120	0.1	
157	44.0	36.5	-95.0	1	3.000	----	0.00		0.0	
174	44.0	36.4	78.3		3.068		16.50	0.009	0.1	
Pipe: 6		0.0	173.3	175	4.1		271.00	120	3.5	
1	44.0	39.8	-78.3	157	3.000	E: 7.0	7.00		0.0	
174	44.0	36.4	95.0		3.068		278.00	0.012	3.5	
Pipe: 7		0.0	0.0		16.6		5.25	120	4.4	
174	44.0	36.4	173.3	180	2.000	T:10.0	10.00		-0.4	
175	45.0	32.0	173.3		2.067		15.25	0.260	4.0	
Pipe: 8		0.0	30.5	S179	16.6		3.75	120	2.3	
175	45.0	32.0	142.8	181	2.000	E: 5.0	5.00		0.0	
180	45.0	29.7	173.3		2.067		8.75	0.260	2.3	
Pipe: 9		0.0	25.6	S181	22.5		15.00	120	9.2	
180	45.0	29.7	91.4	182	1.500	----	0.00		0.0	
181	45.0	20.5	142.8		1.610		15.00	0.613	9.2	
Pipe: 10		0.0	23.2	S183	14.4		15.00	120	4.0	
181	45.0	20.5	45.0	183	1.500	----	0.00		0.0	
182	45.0	16.5	91.4		1.610		15.00	0.269	4.0	
Pipe: 11		0.0	22.5	S185	7.1		14.75	120	1.1	
182	45.0	16.5	22.5	S184	1.500	----	0.00		0.0	
183	45.0	15.4	45.0		1.610		14.75	0.072	1.1	
Pipe: 12		5.60	30.5	Disch	6.5		11.00	120	0.0	
180	45.0	29.7	0.0		1.250	2E: 6.0	12.00		1.7	
S179	41.0	29.7	30.5		1.380	T: 6.0	23.00	0.075	1.7	

Pipe Tag Frm Node To Node	 El (ft) El (ft)	K-fac PT PT	Add Fl (q) Tot.(Q)	Fl To Node/ Disch	Vel Nom ID Act ID	Fit: Eq.Ln. (ft.)	L F T	C Pf/ft.	(Pt) (Pe) (Pf)	 Notes
Pipe: 13		5.60	25.7	Disch	5.5		10.00	120	0.5	
181	45.0	20.5	0.0		1.250	2E: 6.0	12.00		1.7	
S180	41.0	21.0	25.7		1.380	T: 6.0	22.00	0.054	1.2	
Pipe: 14		5.60	25.6	Disch	5.5		11.00	120	0.5	
181	45.0	20.5	0.0		1.250	2E: 6.0	12.00		1.7	
S181	41.0	21.0	25.6		1.380	T: 6.0	23.00	0.054	1.2	
Pipe: 15		5.60	23.2	Disch	5.0		10.00	120	0.7	
182	45.0	16.5	0.0		1.250	2E: 6.0	12.00		1.7	
S182	41.0	17.2	23.2		1.380	T: 6.0	22.00	0.045	1.0	
Pipe: 16		5.60	23.2	Disch	5.0		11.00	120	0.7	
182	45.0	16.5	0.0		1.250	2E: 6.0	12.00		1.7	
S183	41.0	17.2	23.2		1.380	T: 6.0	23.00	0.045	1.0	
Pipe: 17		5.60	22.5	Disch	4.8		10.00	120	0.8	
183	45.0	15.4	0.0		1.250	2E: 6.0	12.00		1.7	
S184	41.0	16.2	22.5		1.380	T: 6.0	22.00	0.043	0.9	
Pipe: 18		5.60	22.5	Disch	4.8		11.00	120	0.8	
183	45.0	15.4	0.0		1.250	2E: 6.0	12.00		1.7	
S185	41.0	16.1	22.5		1.380	T: 6.0	23.00	0.043	1.0	

NOTES (HASS):

(1) Calculations were performed by the HASS 8.5 computer program
under license no. 2707032950 granted by
HRS Systems, Inc.
208 Southside Square
Petersburg, TN 37144
(931) 659-9760

(2) The system has been calculated to provide an average
imbalance at each node of 0.011 gpm and a maximum
imbalance at any node of 0.180 gpm.

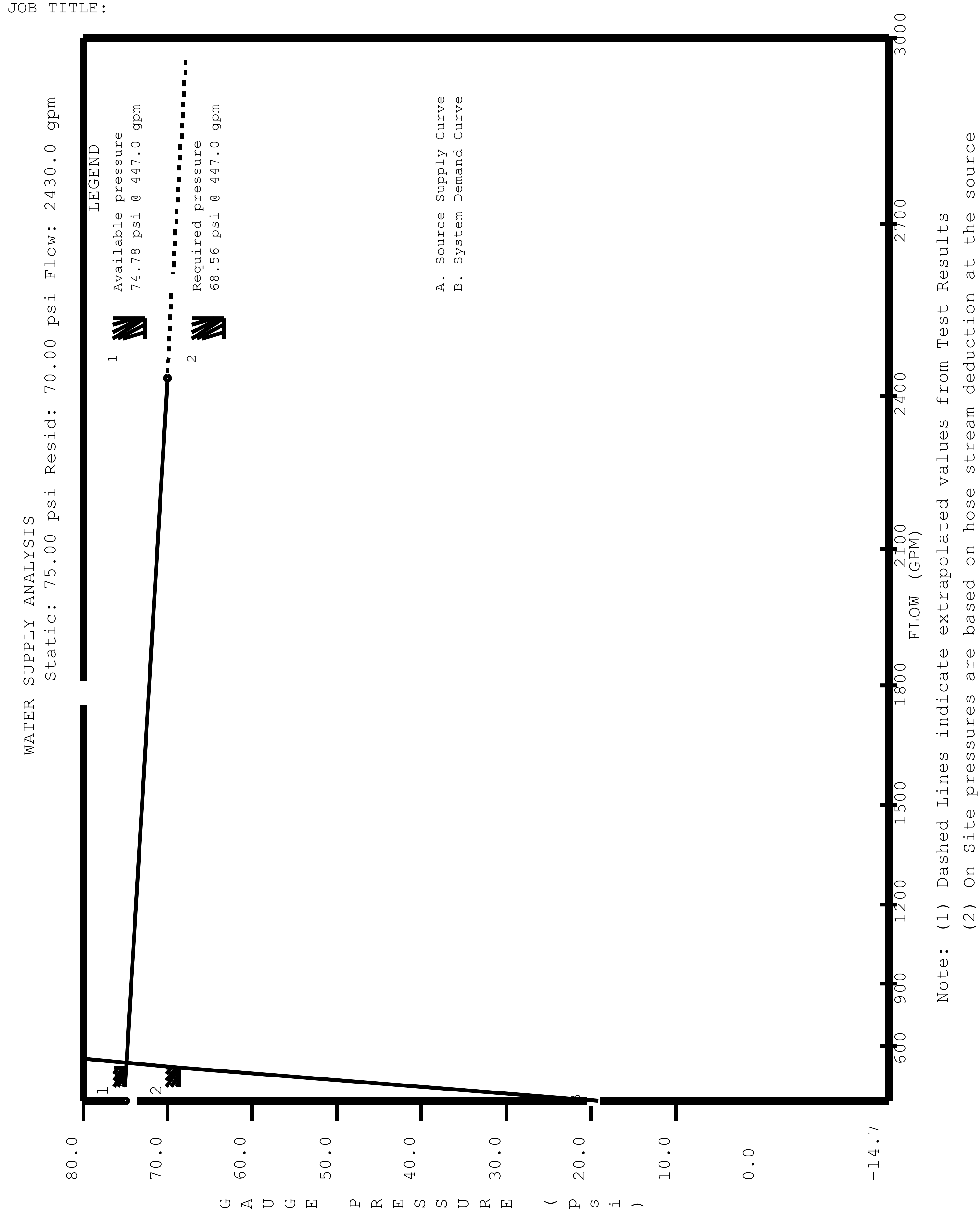
(3) Total pressure at each node is used in balancing the system.
Maximum water velocity is 22.5 ft/sec at pipe 9.

(4) Items listed in bold print on the cover sheet

are automatically transferred from the calculation report.

(5) Available pressure at source node UNDGSRCE under full flow conditions is
74.79 psi compared to the minimum required pressure of 20.00 psi.

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_9.SDF
JOB TITLE:



DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_9.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0		2430.0	74.8		447.0	68.6

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	447.0 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	197.0 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	68.6	447.0	
BOR	0.0	HOSE STREAM	64.4	250.0	
TOR	44.0	- - - -	44.0	- - -	
1	44.0	- - - -	41.3	- - -	
192	44.0	- - - -	37.4	- - -	
217	44.0	- - - -	37.5	- - -	
193	44.0	- - - -	32.5	- - -	
194	44.0	- - - -	29.7	- - -	
197	45.0	- - - -	29.3	- - -	
198	44.0	- - - -	21.1	- - -	
199	45.0	- - - -	16.6	- - -	
200	45.0	- - - -	15.9	- - -	
202	44.0	- - - -	18.6	- - -	
275	44.0	- - - -	15.6	- - -	
195	45.0	- - - -	27.0	- - -	
S214	41.0	K= 5.60	18.5	24.1	
S215	41.0	K= 5.60	19.0	24.4	
S216	41.0	K= 5.60	16.1	22.5	
S217	41.0	K= 5.60	16.9	23.0	
S218	41.0	K= 5.60	16.9	23.0	
S219	41.0	K= 5.60	26.8	29.0	
S221	41.0	K= 5.60	26.7	29.0	
S307	41.0	K= 5.60	15.4	22.0	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_9.SDF
JOB TITLE:

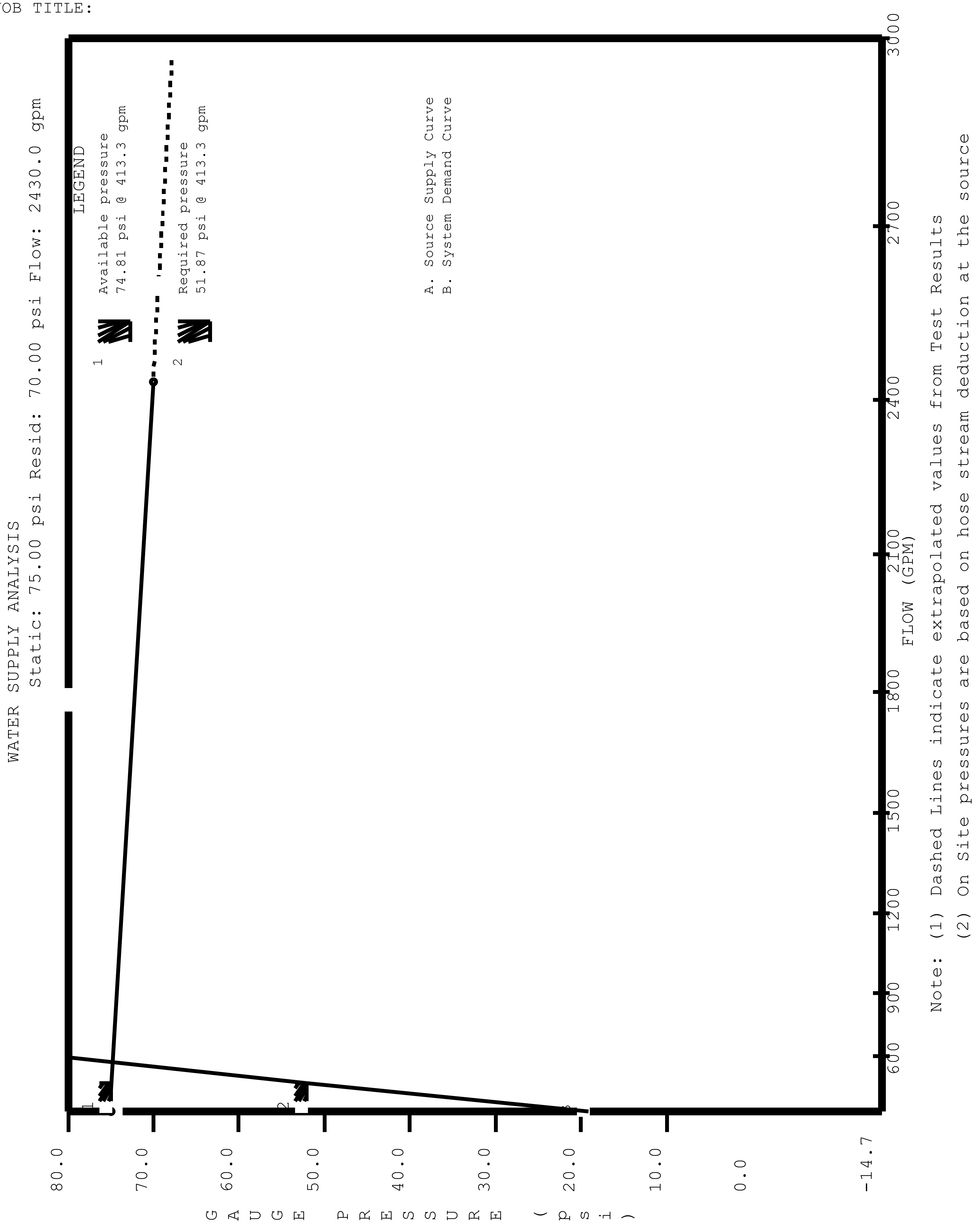
NFPA PIPE DATA

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		Source	250.0	Disch	5.0		300.00	120	4.2	
UNDGSRCE	-3.0	68.6	196.9	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	64.4	447.0		6.065	2G: 6.0	362.00	0.008	2.9	
Pipe: 2		0.0	0.0		5.0	E:10.0	47.00	120	20.4	
BOR	0.0	64.4	196.9	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	44.0	196.9		4.026	G: 2.0	103.00	0.013	1.3	
Pipe: 3		0.0	122.0	217	8.5		49.00	120	2.7	
TOR	44.0	44.0	74.9	192	3.000	E: 7.0	7.00		0.0	
1	44.0	41.3	196.9		3.068		56.00	0.048	2.7	
Pipe: 4		0.0	196.9	193	3.3		452.00	120	3.9	
1	44.0	41.3	-122.0	217	3.000	2E:14.0	29.00		0.0	
192	44.0	37.4	74.9		3.068	T:15.0	481.00	0.008	3.9	
Pipe: 5		0.0	0.0		5.3		184.00	120	3.8	
1	44.0	41.3	122.0	192	3.000	E: 7.0	7.00		0.0	
217	44.0	37.5	122.0		3.068		191.00	0.020	3.8	
Pipe: 6		0.0	196.9	193	5.3		4.00	120	0.1	
217	44.0	37.5	-74.9	1	3.000	----	0.00		0.0	
192	44.0	37.4	122.0		3.068		4.00	0.020	0.1	
Pipe: 7		0.0	0.0		13.2		24.00	120	5.0	
192	44.0	37.4	196.9	194	2.500	T:12.0	12.00		0.0	
193	44.0	32.5	196.9		2.469		36.00	0.139	5.0	
Pipe: 8		0.0	139.0	198	18.8		8.25	120	2.7	
193	44.0	32.5	57.9	195	2.000	----	0.00		0.0	
194	44.0	29.7	196.9		2.067		8.25	0.329	2.7	
Pipe: 9		0.0	29.0	S219	9.1		3.75	120	2.7	
194	44.0	29.7	29.0	S221	1.500	2T:16.0	16.00		-0.4	
195	45.0	27.0	57.9		1.610		19.75	0.116	2.3	
Pipe: 10		0.0	0.0		0.0		10.50	120	0.4	
194	44.0	29.7	0.0		1.500	2T:16.0	16.00		-0.4	
197	45.0	29.3	0.0		1.610		26.50	0.000	0.0	
Pipe: 11		0.0	48.5	202	21.9		14.75	120	8.6	
194	44.0	29.7	90.5	199	1.500	----	0.00		0.0	
198	44.0	21.1	139.0		1.610		14.75	0.583	8.6	
Pipe: 12		0.0	46.0	200	14.3		3.75	120	4.6	
198	44.0	21.1	44.5	275	1.500	E: 4.0	12.00		-0.4	
199	45.0	16.6	90.5		1.610	T: 8.0	15.75	0.264	4.2	

DATE: 5/16/2016ROJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_9.SDF
JOB TITLE:

Pipe Tag Frm Node To Node	 El (ft) El (ft)	K-fac PT PT	Add Fl (q) Tot.(Q)	Fl To Node/ Disch	Vel Nom ID Act ID	Fit: Eq.Ln. (ft.)	L F T	C Pf/ft.	(Pt) (Pe) (Pf)	Notes
Pipe: 13		0.0	22.0	S307	7.0		12.00	120	1.0	
199	45.0	16.6	22.5	S216	1.500	T: 8.0	8.00		0.4	
275	44.0	15.6	44.5		1.610		20.00	0.071	1.4	
Pipe: 14		0.0	23.0	S218	7.3		8.50	120	0.6	
199	45.0	16.6	23.0	S217	1.500	----	0.00		0.0	
200	45.0	15.9	46.0		1.610		8.50	0.075	0.6	
Pipe: 15		0.0	24.4	S215	7.6		26.75	120	2.6	
198	44.0	21.1	24.1	S214	1.500	E: 4.0	4.00		0.0	
202	44.0	18.6	48.5		1.610		30.75	0.083	2.6	
Pipe: 16		5.60	24.1	Disch	5.2		20.00	120	0.1	
202	44.0	18.6	0.0		1.250	3E: 9.0	9.00		1.3	
S214	41.0	18.5	24.1		1.380		29.00	0.048	1.4	
Pipe: 17		5.60	24.4	Disch	5.2		5.00	120	0.5	
202	44.0	18.6	0.0		1.250	2E: 6.0	12.00		1.3	
S215	41.0	19.0	24.4		1.380	T: 6.0	17.00	0.050	0.8	
Pipe: 18		5.60	22.5	Disch	4.8		5.00	120	0.6	
275	44.0	15.6	0.0		1.250	2E: 6.0	12.00		1.3	
S216	41.0	16.1	22.5		1.380	T: 6.0	17.00	0.043	0.7	
Pipe: 19		5.60	22.0	Disch	4.7		20.50	120	0.1	
275	44.0	15.6	0.0		1.250	5E:15.0	15.00		1.3	
S307	41.0	15.4	22.0		1.380		35.50	0.041	1.4	
Pipe: 20		5.60	23.0	Disch	4.9		5.00	120	1.0	
200	45.0	15.9	0.0		1.250	2E: 6.0	12.00		1.7	
S217	41.0	16.9	23.0		1.380	T: 6.0	17.00	0.044	0.8	
Pipe: 21		5.60	23.0	Disch	4.9		8.50	120	1.0	
200	45.0	15.9	0.0		1.250	3E: 9.0	9.00		1.7	
S218	41.0	16.9	23.0		1.380		17.50	0.044	0.8	
Pipe: 22		5.60	29.0	Disch	6.2		15.00	120	0.3	
195	45.0	27.0	0.0		1.250	3E: 9.0	15.00		1.7	
S221	41.0	26.7	29.0		1.380	T: 6.0	30.00	0.068	2.0	
Pipe: 23		5.60	29.0	Disch	6.2		20.00	120	0.2	
195	45.0	27.0	0.0		1.250	3E: 9.0	9.00		1.7	
S219	41.0	26.8	29.0		1.380		29.00	0.068	2.0	

DATE: 5/16/2016OJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_10.SDF
JOB TITLE:



DATE: 5/16/2016OJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_10.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI) @	FLOW (GPM)	AVAIL. PRESS. (PSI) @	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0	2430.0	74.8	413.3	51.9

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	413.3 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	163.3 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	51.9	413.3	
BOR	0.0	HOSE STREAM	48.1	250.0	
TOR	44.0	- - - -	28.1	- - -	
1	44.0	- - - -	26.2	- - -	
192	44.0	- - - -	23.5	- - -	
217	44.0	- - - -	23.5	- - -	
193	44.0	- - - -	19.9	- - -	
194	44.0	- - - -	19.7	- - -	
197	45.0	- - - -	17.8	- - -	
203	44.0	- - - -	19.7	- - -	
204	44.0	- - - -	19.0	- - -	
207	45.0	- - - -	17.2	- - -	
208	44.0	- - - -	16.5	- - -	
209	45.0	- - - -	15.6	- - -	
211	45.0	- - - -	15.5	- - -	
S222	41.0	K= 5.60	18.6	24.1	
S223	41.0	K= 5.60	18.2	23.9	
S224	41.0	K= 5.60	17.6	23.5	
S225	41.0	K= 5.60	18.0	23.7	
S231	41.0	K= 5.60	16.5	22.8	
S232	41.0	K= 5.60	16.5	22.8	
S233	41.0	K= 5.60	16.1	22.5	

DATE: 5/16/2016OJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_10.SDF
JOB TITLE:

NFPA PIPE DATA

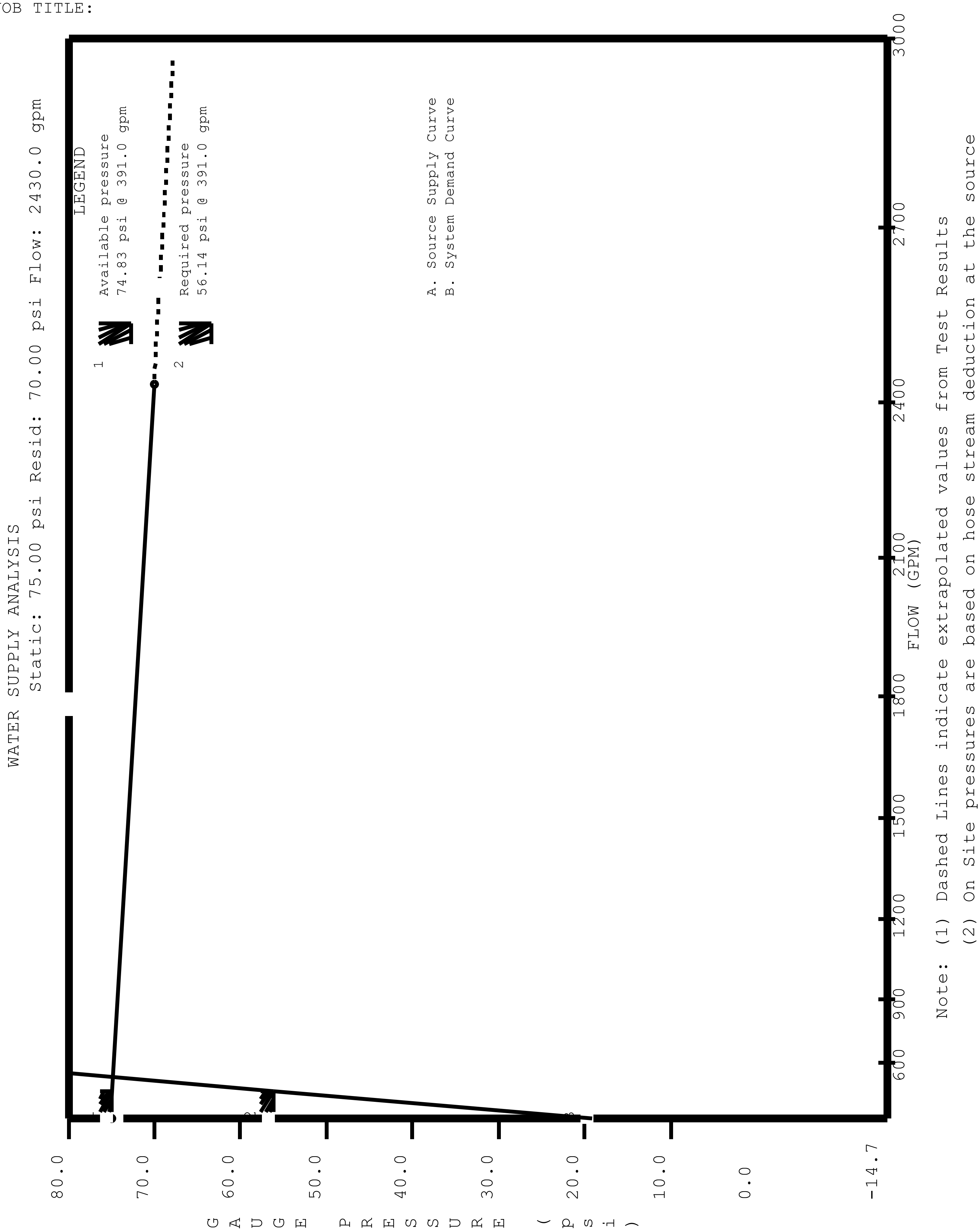
Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 1		Source	250.0	Disch	4.6		300.00	120	3.8	
UNDGSRCE	-3.0	51.9	163.3	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	48.1	413.3		6.065	2G: 6.0	362.00	0.007	2.5	
Pipe: 2		0.0	0.0		4.1	E:10.0	47.00	120	20.0	
BOR	0.0	48.1	163.3	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	28.1	163.3		4.026	G: 2.0	103.00	0.009	0.9	
Pipe: 3		0.0	101.2	217	7.1		49.00	120	1.9	
TOR	44.0	28.1	62.1	192	3.000	E: 7.0	7.00		0.0	
1	44.0	26.2	163.3		3.068		56.00	0.034	1.9	
Pipe: 4		0.0	163.3	193	2.7		452.00	120	2.7	
1	44.0	26.2	-101.2	217	3.000	2E:14.0	29.00		0.0	
192	44.0	23.5	62.1		3.068	T:15.0	481.00	0.006	2.7	
Pipe: 5		0.0	0.0		4.4		184.00	120	2.7	
1	44.0	26.2	101.2	192	3.000	E: 7.0	7.00		0.0	
217	44.0	23.5	101.2		3.068		191.00	0.014	2.7	
Pipe: 6		0.0	163.3	193	4.4		4.00	120	0.1	
217	44.0	23.5	-62.1	1	3.000	----	0.00		0.0	
192	44.0	23.5	101.2		3.068		4.00	0.014	0.1	
Pipe: 7		0.0	115.3	203	10.9		24.00	120	3.5	
192	44.0	23.5	48.0	194	2.500	T:12.0	12.00		0.0	
193	44.0	19.9	163.3		2.469		36.00	0.098	3.5	
Pipe: 8		0.0	0.0		4.6		8.25	120	0.2	
193	44.0	19.9	48.0	197	2.000	----	0.00		0.0	
194	44.0	19.7	48.0		2.067		8.25	0.024	0.2	
Pipe: 9		0.0	23.9	S223	7.6		10.50	120	1.9	
194	44.0	19.7	24.1	S222	1.500	2E: 8.0	8.00		-0.4	
197	45.0	17.8	48.0		1.610		18.50	0.082	1.5	
Pipe: 10		0.0	0.0		7.7		4.75	120	0.2	
193	44.0	19.9	115.3	204	2.500	----	0.00		0.0	
203	44.0	19.7	115.3		2.469		4.75	0.051	0.2	
Pipe: 11		0.0	68.0	208	7.7		6.75	120	0.7	
203	44.0	19.7	47.3	207	2.500	E: 6.0	6.00		0.0	
204	44.0	19.0	115.3		2.469		12.75	0.051	0.7	
Pipe: 12		0.0	23.7	S225	7.4		5.75	120	1.8	
204	44.0	19.0	23.5	S224	1.500	E: 4.0	12.00		-0.4	
207	45.0	17.2	47.3		1.610	T: 8.0	17.75	0.079	1.4	

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 13		0.0	45.3	211	10.7		16.50	120	2.6	
204	44.0	19.0	22.8	209	1.500	----	0.00		0.0	
208	44.0	16.5	68.0		1.610		16.50	0.155	2.6	
Pipe: 14		0.0	0.0		3.6		4.00	120	0.8	
208	44.0	16.5	22.8	S231	1.500	2T:16.0	16.00		-0.4	
209	45.0	15.6	22.8		1.610		20.00	0.021	0.4	
Pipe: 15		0.0	22.5	S233	7.1		7.00	120	0.9	
208	44.0	16.5	22.8	S232	1.500	----	0.00		-0.4	
211	45.0	15.5	45.3		1.610		7.00	0.073	0.5	
Pipe: 16		5.60	24.1	Disch	5.2		7.00	120	0.8	
197	45.0	17.8	0.0		1.250	2E: 6.0	12.00		1.7	
S222	41.0	18.6	24.1		1.380	T: 6.0	19.00	0.048	0.9	
Pipe: 17		5.60	23.9	Disch	5.1		19.00	120	0.4	
197	45.0	17.8	0.0		1.250	3E: 9.0	9.00		1.7	
S223	41.0	18.2	23.9		1.380		28.00	0.048	1.3	
Pipe: 18		5.60	23.5	Disch	5.0		19.00	120	0.4	
207	45.0	17.2	0.0		1.250	3E: 9.0	9.00		1.7	
S224	41.0	17.6	23.5		1.380		28.00	0.046	1.3	
Pipe: 19		5.60	23.7	Disch	5.1		8.00	120	0.8	
207	45.0	17.2	0.0		1.250	2E: 6.0	12.00		1.7	
S225	41.0	18.0	23.7		1.380	T: 6.0	20.00	0.047	0.9	
Pipe: 20		5.60	22.8	Disch	4.9		10.00	120	0.9	
209	45.0	15.6	0.0		1.250	3E: 9.0	9.00		1.7	
S231	41.0	16.5	22.8		1.380		19.00	0.043	0.8	
Pipe: 21		5.60	22.8	Disch	4.9		5.00	120	1.0	
211	45.0	15.5	0.0		1.250	2E: 6.0	12.00		1.7	
S232	41.0	16.5	22.8		1.380	T: 6.0	17.00	0.043	0.7	
Pipe: 22		5.60	22.5	Disch	4.8		17.00	120	0.6	
211	45.0	15.5	0.0		1.250	3E: 9.0	9.00		1.7	
S233	41.0	16.1	22.5		1.380		26.00	0.043	1.1	

NOTES (HASS):

(1) Calculations were performed by the HASS 8.5 computer program
under license no. 2707032950 granted by
HRS Systems, Inc.
208 Southside Square
Petersburg, TN 37144
(931) 659-9760

DATE: 5/16/2016OJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_11.SDF
JOB TITLE:



DATE: 5/16/2016OJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_11.SDF
JOB TITLE:

NFPA WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
UNDGSRCE	75.0	70.0		2430.0	74.8		391.0	56.1

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	391.0 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	0.0 GPM
OTHER HOSE STREAM ALLOWANCES	250.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	141.0 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
UNDGSRCE	-3.0	SOURCE	56.1	391.0	
BOR	0.0	HOSE STREAM	52.6	250.0	
TOR	44.0	- - - -	32.8	- - -	
1	44.0	- - - -	31.4	- - -	
192	44.0	- - - -	29.3	- - -	
217	44.0	- - - -	29.3	- - -	
193	44.0	- - - -	26.6	- - -	
194	44.0	- - - -	26.6	- - -	
197	45.0	- - - -	26.2	- - -	
203	44.0	- - - -	26.3	- - -	
204	44.0	- - - -	25.3	- - -	
208	44.0	- - - -	22.4	- - -	
209	45.0	- - - -	18.4	- - -	
210	45.0	- - - -	17.7	- - -	
212	44.0	- - - -	19.7	- - -	
215	45.0	- - - -	16.3	- - -	
216	45.0	- - - -	15.5	- - -	
S231	41.0	K= 5.60	19.2	24.6	
S229	41.0	K= 5.60	18.2	23.9	
S230	41.0	K= 5.60	18.6	24.1	
S238	41.0	K= 5.60	17.3	23.3	
S239	41.0	K= 5.60	16.3	22.6	
S240	41.0	K= 5.60	16.1	22.5	

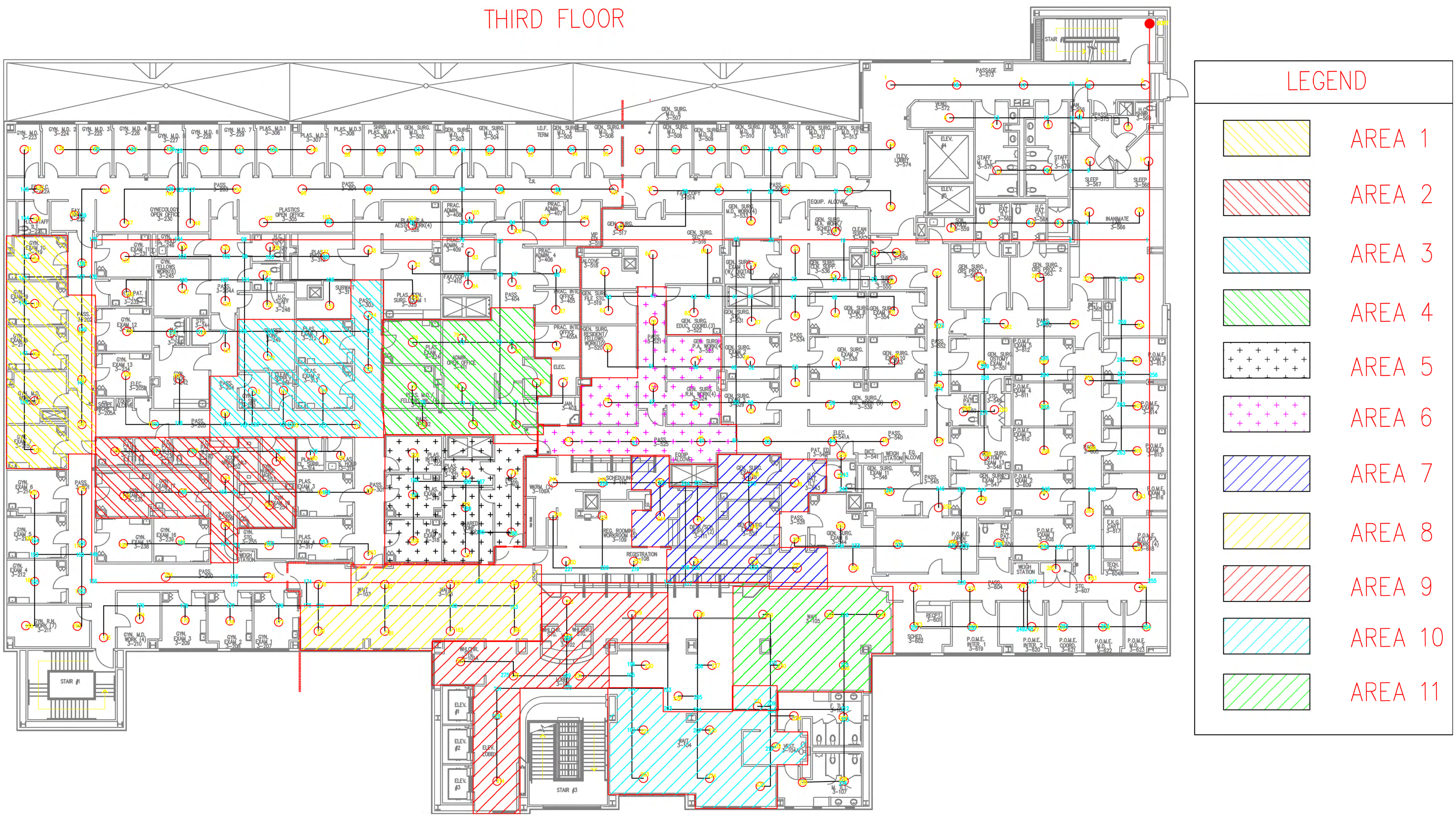
NFPA PIPE DATA

Pipe Tag Frm Node To Node	 El (ft) El (ft)	K-fac PT PT	Add Fl (q) Tot.(Q)	Fl To Node/ Disch	Vel Nom ID Act ID	Fit: Eq.Ln. (ft.)	L F T	C Pf/ft.	(Pt) (Pe) (Pf)	Notes
Pipe: 1		Source	250.0	Disch	4.3		300.00	120	3.5	
UNDGSRCE	-3.0	56.1	141.0	TOR	6.000	4E:56.0	62.00		-1.3	
BOR	0.0	52.6	391.0		6.065	2G: 6.0	362.00	0.006	2.2	
Pipe: 2		0.0	0.0		3.6	E:10.0	47.00	120	19.8	
BOR	0.0	52.6	141.0	1	4.000	2C:44.0	56.00		-19.1	
TOR	44.0	32.8	141.0		4.026	G: 2.0	103.00	0.007	0.7	
Pipe: 3		0.0	87.3	217	6.1		49.00	120	1.5	
TOR	44.0	32.8	53.6	192	3.000	E: 7.0	7.00		0.0	
1	44.0	31.4	141.0		3.068		56.00	0.026	1.5	
Pipe: 4		0.0	141.0	193	2.3		452.00	120	2.1	
1	44.0	31.4	-87.3	217	3.000	2E:14.0	29.00		0.0	
192	44.0	29.3	53.6		3.068	T:15.0	481.00	0.004	2.1	
Pipe: 5		0.0	0.0		3.8		184.00	120	2.0	
1	44.0	31.4	87.3	192	3.000	E: 7.0	7.00		0.0	
217	44.0	29.3	87.3		3.068		191.00	0.011	2.0	
Pipe: 6		0.0	141.0	193	3.8		4.00	120	0.0	
217	44.0	29.3	-53.6	1	3.000	----	0.00		0.0	
192	44.0	29.3	87.3		3.068		4.00	0.011	0.0	
Pipe: 7		0.0	0.0		9.4		24.00	120	2.7	
192	44.0	29.3	141.0	203	2.500	T:12.0	12.00		0.0	
193	44.0	26.6	141.0		2.469		36.00	0.075	2.7	
Pipe: 8		0.0	0.0		0.0		8.25	120	0.0	
194	44.0	26.6	0.0		2.000	----	0.00		0.0	
193	44.0	26.6	0.0		2.067		8.25	0.000	0.0	
Pipe: 9		0.0	0.0		0.0		10.50	120	0.4	
194	44.0	26.6	0.0		1.500	2E: 8.0	8.00		-0.4	
197	45.0	26.2	0.0		1.610		18.50	0.000	0.0	
Pipe: 10		0.0	0.0		9.4		4.75	120	0.4	
193	44.0	26.6	141.0	204	2.500	----	0.00		0.0	
203	44.0	26.3	141.0		2.469		4.75	0.075	0.4	
Pipe: 11		0.0	0.0		9.4		6.75	120	1.0	
203	44.0	26.3	141.0	208	2.500	E: 6.0	6.00		0.0	
204	44.0	25.3	141.0		2.469		12.75	0.075	1.0	
Pipe: 13		0.0	68.4	212	13.5		16.50	120	2.9	
204	44.0	25.3	72.6	209	2.000	----	0.00		0.0	
208	44.0	22.4	141.0		2.067		16.50	0.177	2.9	

DATE: 5/16/2016OJECT BUILDING\MCS BUILDING HYDRAULIC CALCS\NEW\MCS_11.SDF
JOB TITLE:

Pipe Tag		K-fac	Add Fl	Fl To	Vel	Fit:	L	C	(Pt)	
Frm Node	El (ft)	PT	(q)	Node/	Nom ID	Eq.Ln.	F		(Pe)	Notes
To Node	El (ft)	PT	Tot.(Q)	Disch	Act ID	(ft.)	T	Pf/ft.	(Pf)	
Pipe: 14		0.0	48.0	210	11.4		4.00	120	3.9	
208	44.0	22.4	24.6	S231	1.500	2T:16.0	16.00		-0.4	
209	45.0	18.4	72.6		1.610		20.00	0.175	3.5	
Pipe: 20		5.60	24.6	Disch	5.3		10.00	120	0.8	
209	45.0	18.4	0.0		1.250	3E: 9.0	9.00		1.7	
S231	41.0	19.2	24.6		1.380		19.00	0.050	1.0	
Pipe: 21		0.0	24.1	S230	7.6		9.50	120	0.8	
209	45.0	18.4	23.9	S229	1.500	----	0.00		0.0	
210	45.0	17.7	48.0		1.610		9.50	0.082	0.8	
Pipe: 22		0.0	0.0		10.8		16.75	120	2.6	
208	44.0	22.4	68.4	215	1.500	----	0.00		0.0	
212	44.0	19.7	68.4		1.610		16.75	0.157	2.6	
Pipe: 23		0.0	23.3	S238	10.8		11.00	120	3.4	
212	44.0	19.7	45.1	216	1.500	2E: 8.0	8.00		-0.4	
215	45.0	16.3	68.4		1.610		19.00	0.157	3.0	
Pipe: 24		0.0	22.5	S240	7.1		11.75	120	0.9	
215	45.0	16.3	22.6	S239	1.500	----	0.00		0.0	
216	45.0	15.5	45.1		1.610		11.75	0.073	0.9	
Pipe: 25		5.60	23.9	Disch	5.1		17.00	120	0.5	
210	45.0	17.7	0.0		1.250	3E: 9.0	9.00		1.7	
S229	41.0	18.2	23.9		1.380		26.00	0.047	1.2	
Pipe: 26		5.60	24.1	Disch	5.2		5.00	120	0.9	
210	45.0	17.7	0.0		1.250	2E: 6.0	12.00		1.7	
S230	41.0	18.6	24.1		1.380	T: 6.0	17.00	0.048	0.8	
Pipe: 27		5.60	23.3	Disch	5.0		5.00	120	1.0	
215	45.0	16.3	0.0		1.250	2E: 6.0	12.00		1.7	
S238	41.0	17.3	23.3		1.380	T: 6.0	17.00	0.045	0.8	
Pipe: 28		5.60	22.6	Disch	4.9		9.00	120	0.8	
216	45.0	15.5	0.0		1.250	2E: 6.0	12.00		1.7	
S239	41.0	16.3	22.6		1.380	T: 6.0	21.00	0.043	0.9	
Pipe: 29		5.60	22.5	Disch	4.8		13.00	120	0.7	
216	45.0	15.5	0.0		1.250	2E: 6.0	12.00		1.7	
S240	41.0	16.1	22.5		1.380	T: 6.0	25.00	0.043	1.1	

Appendix E


THIRD FLOOR
LEGEND
AREA 1
AREA 2
AREA 3
AREA 4
AREA 5
AREA 6
AREA 7
AREA 8
AREA 9
AREA 10
AREA 11

Appendix F

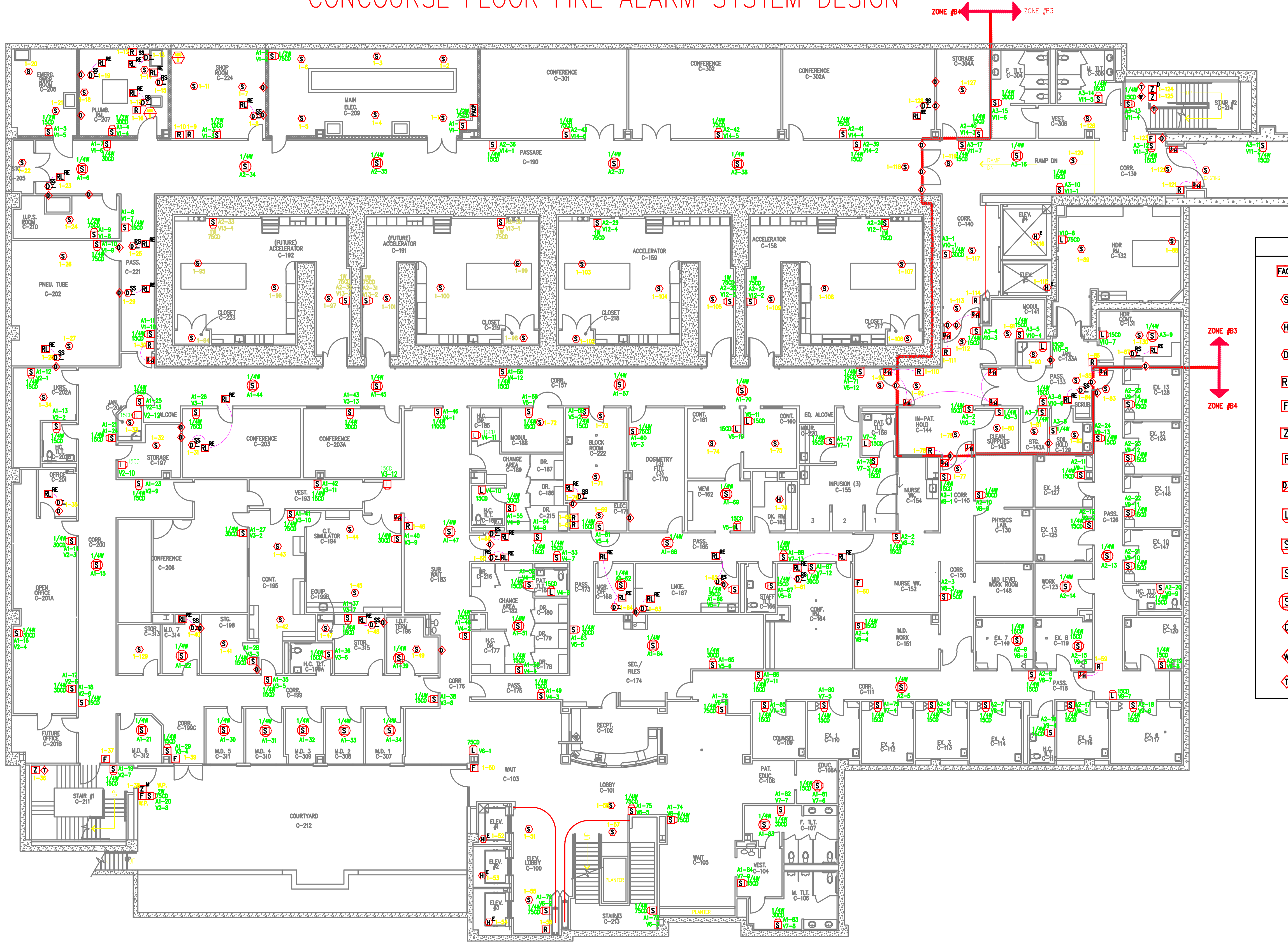
Project name:	Area 1 Hass Verification												Date:		
Step No.	Nozzle Ident and Location	Flow in gpm		Pipe size	Pipe Fittings and Devices	Equivalent Pipe Length		Friction loss (psi/ft)		Pressure Summary		Normal Pressure			Notes
	S158 Sprk 1	q	22.5			L		C=		Pt	0.0	Pt		k=	5.6
						F				Pe		Pv			q = k * (Pt)^1/2
		Q	0.0			T		pf		Pf		Pn		Pt=	16.1
	23 Pipe	q	22.5	1 1/4	3E	L	16	C=	120	Pt	16.1	Pt			148 to S158
				1.38		F	9			Pe	-1.7	Pv			
		Q	22.5			T	25	pf	0.043	Pf	1.064	Pn			
	22 Pipe	q	22.7	1 1/4	2ET	L	5	C=	120	Pt	15.43	Pt			148 to S157
				1.38		F	12			Pe	-1.7	Pv			
		Q				T	17	pf	0.043	Pf	0.735	Pn			
	S157 Sprk 2	q	22.7			L		C=		Pt	16.43	Pt		k=	5.6
						F				Pe		Pv			q = k * (Pt)^1/2
		Q	22.7			T		pf		Pf		Pn		q=	22.7
	15 Pipe	q	45.2	1 1/2		L	10.75	C=	120	Pt	15.43	Pt			148 to 147
				1.61		F				Pe		Pv			
		Q	45.2			T	10.75	pf	0.073	Pf	0.8	Pn			
	21 Pipe	q	23.2	1 1/4	2ET	L	5	C=	120	Pt	16.22	Pt			147 to S156
				1.38		F	12			Pe	-1.7	Pv			
		Q				T	17	pf	0.045	Pf	0.766	Pn			
	S156 Sprk3	q	23.2			L		C=		Pt	17.18	Pt		k=	5.6
						F				Pe		Pv			q = k * (Pt)^1/2
		Q	68.4			T		pf		Pf		Pn		q=	23.2
	14 Pipe	q	68.4	1 1/2		L	11.5	C=	120	Pt	16.22	Pt			147 to 146
				1.61		F				Pe		Pv			
		Q	68.4			T	11.5	pf	0.157	Pf	1.8	Pn			
	20 Pipe	q	24.4	1 1/4		L	16.75	C=	120	Pt	18.02	Pt			146 to S155
				1.38		F				Pe	-1.7	Pv			
		Q				T	16.75	pf	0.049	Pf	0.828	Pn			
	S155 Sprk4	q	24.4			L		C=		Pt	18.93	Pt		k=	5.60
						F				Pe		Pv			q = k * (Pt)^1/2
		Q				T		pf		Pf		Pn		q=	24.4
	13 Pipe	q	92.8	1 1/2	ET	L	7	C=	120	Pt	18.02	Pt			146 to 142
				1.61		F	12			Pe	-0.4	Pv			
		Q				T	19	pf	0.276	Pf	5.247	Pn			
	12 Pipe	q	27.1	1 1/2	ET	L	5	C=	120	Pt	23.70	Pt			142 to 143
				1.61		F	12			Pe	-0.4	Pv			
		Q				T	17	pf	0.028	Pf	0.48	Pn			
	19 Pipe	q	27.1	1 1/4	2ET	L	5	C=	120	Pt	22.79	Pt			143 to S154
				1.38		F	12			Pe	-1.7	Pv			
		Q				T	17	pf	0.060	Pf	1.021	Pn			
	S154 Sprk5	q	27.1			L		C=		Pt	23.50	Pt		k=	5.6
						F				Pe		Pv			q = k * (Pt)^1/2
		Q				T		pf		Pf		Pn		q=	27.1
	11 Pipe	q	119.9	2		L	13	C=	120	Pt	23.70	Pt			142 to 137
				2.067		F				Pe		Pv			
		Q				T	13	pf	0.131	Pf	1.709	Pn			
	9 Pipe	q	76.0	1 1/2	ET	L	12	C=	120	Pt	25.41	Pt			137 to 140
				1.61		F	12			Pe	-0.4	Pv			
		Q				T	24	pf	0.191	Pf	4.577	Pn			
	16 Pipe	q	25.8	1 1/4	2ET	L	5	C=	120	Pt	20.40	Pt			140 to S161
				1.38		F	12			Pe	-1.7	Pv			
		Q				T	17	pf	0.055	Pf	0.932	Pn			
	10 Pipe	q	50.2	1 1/2		L	11.5	C=	120	Pt	20.40	Pt			140 to 141
				1.61		F				Pe		Pv			
		Q				T	11.5	pf	0.088	Pf	1.018	Pn			
	17 Pipe	q	25.2	1 1/4	2ET	L	5	C=	120	Pt	19.39	Pt			141 to S160
				1.38		F	12			Pe	-1.7	Pv			
		Q				T	17	pf	0.052	Pf	0.892	Pn			
	18 Pipe	q	25.0	1 1/4	3E	L	15.5	C=	120	Pt	19.39	Pt			141 to S159
				1.38		F	9			Pe	-1.7	Pv			
		Q				T	24.5	pf	0.052	Pf	1.262	Pn			
	S161 Sprk6	q	25.8			L		C=		Pt	21.20	Pt		k=	5.6
						F				Pe		Pv			q = k * (Pt)^1/2
		Q				T		pf		Pf		Pn		q=	25.8
	S160 Sprk7	q	25.2			L		C=		Pt	20.23	Pt		k=	5.6
						F				Pe		Pv			q = k * (Pt)^1/2
		Q				T		pf		Pf		Pn		q=	25.2
	S159 Sprk8	q	25.0			L		C=		Pt	19.86	Pt		k=	5.6
						F				Pe		Pv			q = k * (Pt)^1/2
		Q				T		pf		Pf		Pn		q=	25.0
	8 Pipe	q	195.9	1 1/2	T	L	3	C=	120	Pt	25.41	Pt			137 to 136
				1.61		F	8			Pe		Pv			
		Q				T	11	pf	1.100	Pf	12.105	Pn			
	7 Pipe	q	86.5	3	E	L	70	C=	120	Pt	37.52	Pt			136 to 156
				3.068		F	7			Pe		Pv			
		Q				T	77	pf	0.010	Pf	0.808	Pn			
	6 Pipe	q	86.5	3	ET	L	320	C=	120	Pt	38.33	Pt			156 to 1
				3.068		F	22			Pe		Pv			
		Q				T	342	pf	0.010	Pf	3.591	Pn			
	5 Pipe	q	109.4	3	E	L	8.5	C=	120	Pt	37.52	Pt			135 to 136
				3.068		F	7			Pe		Pv			
		Q				T	15.5	pf	0.016	Pf	0.251	Pn			
	4 Pipe	q	109.4	3	T	L	241	C=	120	Pt	37.77	Pt			135 to 1
				3.068		F	15			Pe		Pv			
		Q				T	256	pf	0.016	Pf	4.148	Pn			
	3 Pipe	q	195.9	3	E	L	49	C=	120	Pt	41.92	Pt			1 to TOR
				3.068		F	7			Pe		Pv			
		Q				T	56	pf	0.048	Pf	2.667	Pn			
	2 Pipe	q	195.9	4	E2CG	L	47	C=	120	Pt	44.59	Pt			TOR to BOR
				4.026		F	56			Pe	-19.1	Pv			
		Q				T	103	pf	0.013	Pf	1.306	Pn			
	1 Pipe	q	195.9	6	4E2G	L	300	C=	120	Pt	64.94	Pt			BOR to
			+250 GPM	6.065		F	62			Pe	-1.3	Pv			UNDGSRCE
		Q	445.9			T	362	pf	0.008	Pf	2.858	Pn			(add hose allow.)
	Final Demand	**q**	**445.9**			**L**		**C=**		**Pt**	**69.1**	**Pt**			
						F				**Pe**		**Pv**			
		Q				**T**		**pf**		**Pf**		**Pn**			

Appendix G

FIRE ALARM MATRIX	ANNUNCIATE ON FIRE ALARM PANEL AS ALARM	ANNUNCIATE ON FIRE ALARM PANEL AS TROUBLE	ANNUNCIATE ON FIRE ALARM PANEL AS SUPERVISORY	ACTIVATE SPEAKER/STROBE & STROBE IN ASSOCIATED ZONES	ACTIVATE PRIMARY ELEVATOR RECALL	ACTIVATE AUXILIARY ELEVATOR RECALL	SEND SIGNAL TO ELEVATOR SHUNT TRIP PANEL	SEND SIGNAL TO RED HAT ELEVATOR CAB LIGHT	ACTIVATE DOOR HOLDER RELEASE ON FLOOR OF INCIDENCE	CLOSE ASSOCIATED FIRE/SMOKE DAMPER ZONE	ANNUNCIATE ON FIRE ALARM ANNUNCIATION PANEL AS ALARM	ANNUNCIATE ON FIRE ALARM ANNUNCIATION PANEL AS TROUBLE	ANNUNCIATE ON FIRE ALARM ANNUNCIATION PANEL AS SUPERVISORY	SHUTDOWN ASSOCIATED AHU UNIT & EXHAUST FAN	SEND ALARM SIGNAL TO CENTRAL STATION AS ALARM	SEND WATERFLOW SIGNAL TO CENTRAL STATION AS ALARM	SEND SUPERVISORY SIGNAL TO CENTRAL STATION AS SUPERVISORY	SEND TROUBLE SIGNAL TO CENTRAL STATION AS TROUBLE
SINGLE ZONE AREA SMOKE DETECTOR ACTIVATION	X			X					X	X	X				X			
SINGLE ZONE AREA THERMAL DETCTOR ACTIVATION	X			X					X	X	X				X			
SINGLE ZONE MANUAL PULL STATION ACTIVATION	X			X					X	X	X				X			
SINGLE ZONE ACTIVATION OF SPRINKLER SYSTEM WATERFLOW SWITCH	X			X					X	X	X				X	X		
TWO ZONE AREA SMOKE DETECTOR ACTIVATION	X			X					X	X	X			X	X			
TWO ZONE AREA THERMAL DETCTOR ACTIVATION	X			X					X	X	X			X	X			
TWO ZONE MANUAL PULL STATION ACTIVATION	X			X					X	X	X			X	X	X		
TWO ZONE ACTIVATION OF SPRINKLER SYSTEM WATERFLOW SWITCH	X			X					X	X	X				X			
ACTIVATION OF DUCT-MOUNTED SMOKE DETECTOR ASSOCIATED WITH MAIN AHU UNITS			X							X			X	X			X	
ACTIVATION OF DUCT-MOUNTED SMOKE DETECTOR ASSOCIATED WITH FIRE/SMOKE DAMPERS			X							X			X				X	
ACTIVATION OF TWO (2) CROSS ZONE DUCT-MOUNTED SMOKE DETECTORS			X							X			X	X			X	
ELEVATOR LOBBY SMOKE DETECTOR ON FIRST FLOOR	X			X		X			X	X	X				X			
ELEVATOR LOBBY SMOKE DETECTOR OTHER THAN FIRST FLOOR	X			X	X				X	X	X				X			
ELEVATOR MECHANICAL ROOM SMOKE DETECTOR	X			X	X			X	X	X	X				X			
ELEVATOR MECHANICAL ROOM THERMAL DETECTOR				X			X											
TOP OF ELEVATOR SHAFT SMOKE DETECTOR								X										
TOP OF ELEVATOR SHAFT THERMAL DETECTOR							X											
TROUBLE CONDITION												X						X
ACTIVATION OF SPRINKLER SYSTEM TAMPER SWITCH													X				X	

Appendix H

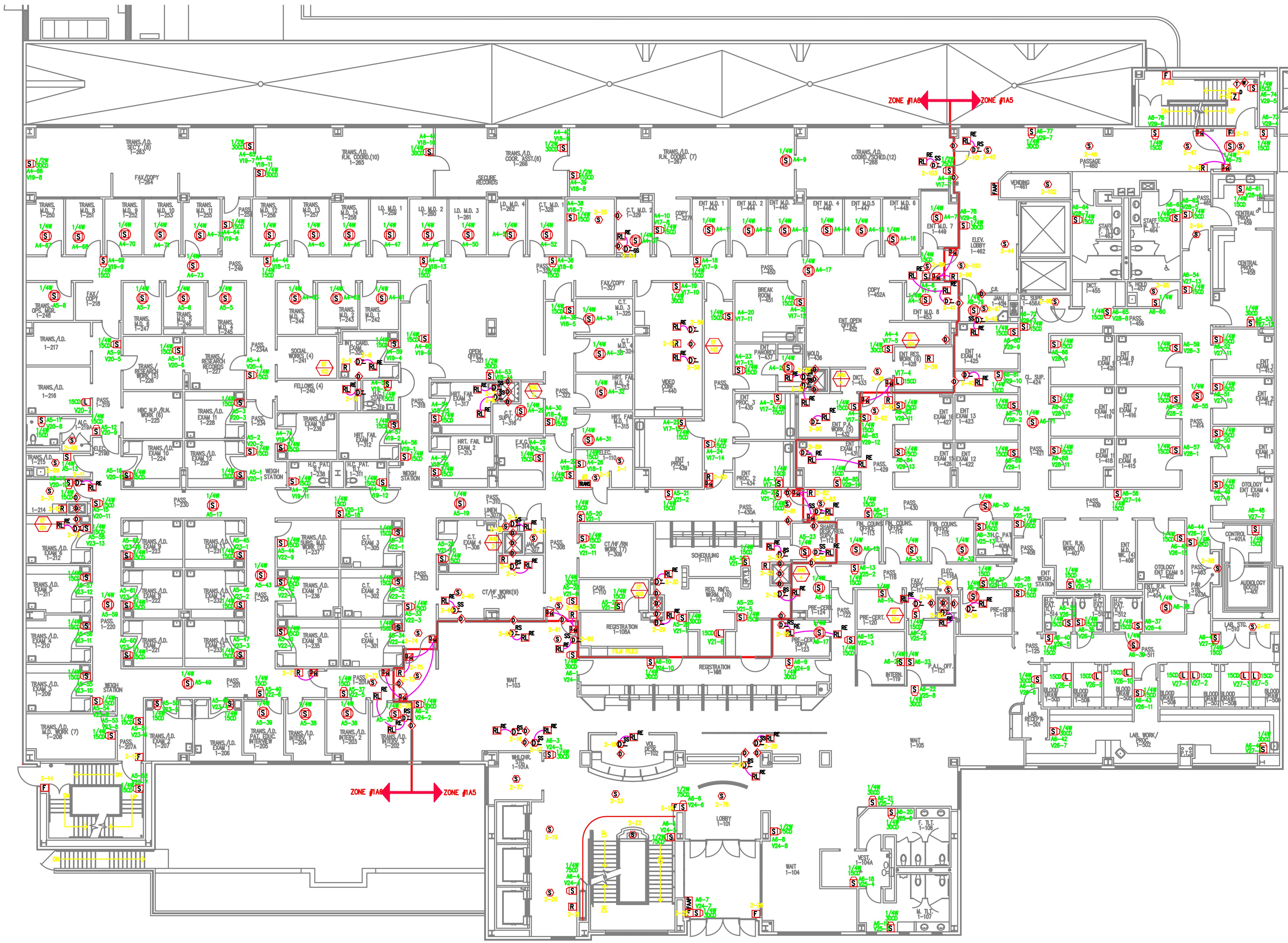
CONCOURSE FLOOR FIRE ALARM SYSTEM DESIGN



LEGEND

Symbol	Description
FACP	FIRE ALARM CONTROL PANEL
S	CEILING MOUNTED SMOKE DETECTOR
H E	CEILING MOUNTED THERMAL DETECTOR
D SS	DUCT DETECTOR HOUSING
RL RE	ROUND REMOTE ALARM INDICATING LAMP
F	MANUAL PULL STATION
Z	INTERFACE MODULE
R	INTERFACE MODULE WIRELAY
DH	MAGNETIC DOOR HOLDER
L	WALL MOUNTED FIRE ALARM STROBE
S	SYNCHRONOUS FIRE ALARM SPEAKER/STROBE
S	WALL MOUNTED FIRE ALARM SPEAKER
S	CEILING MOUNTED FIRE ALARM SPEAKER
D	FIRE SMOKE DAMPER
W	WATER FLOW SWITCH
T	TAMPER SWITCH

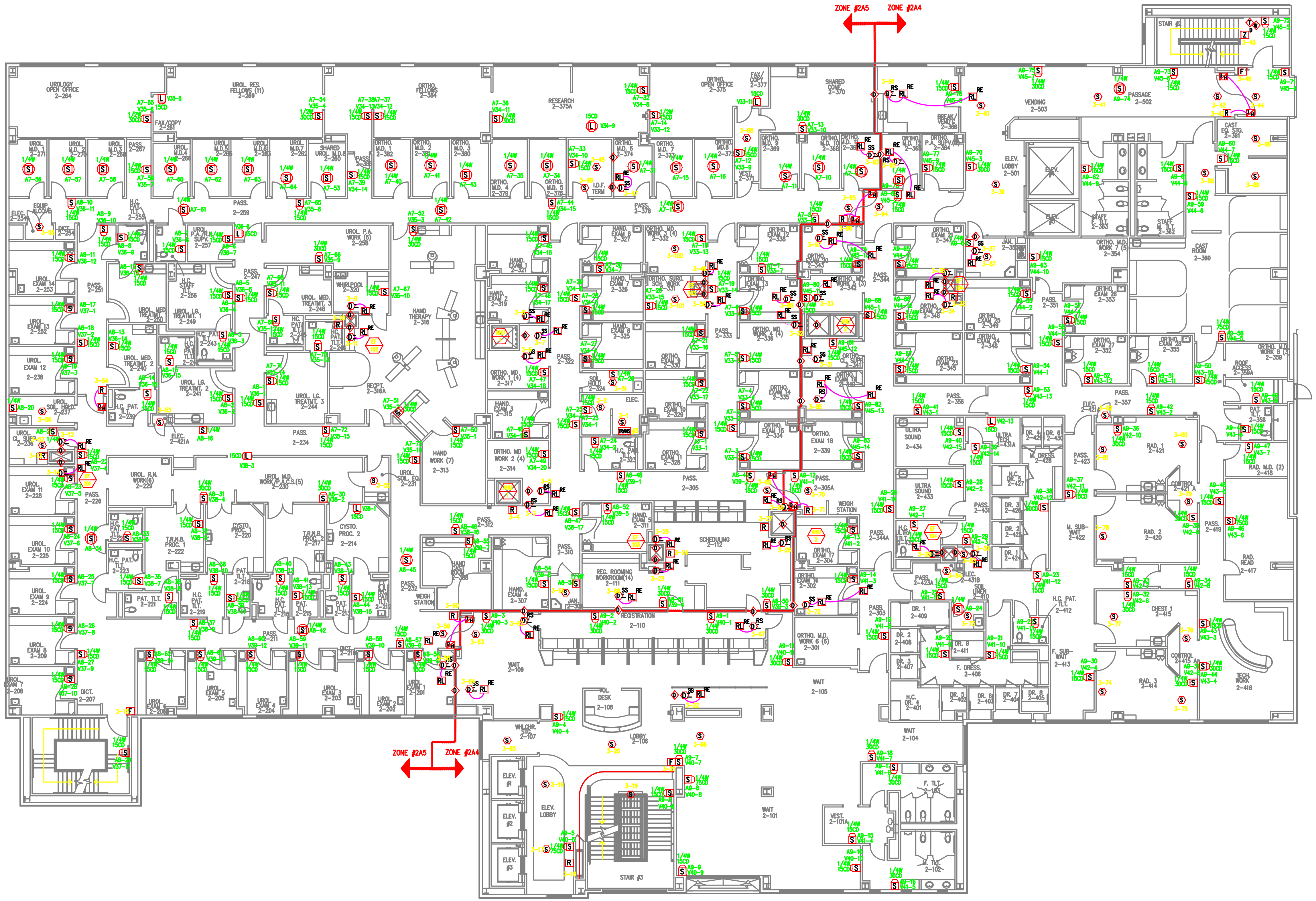
FIRST FLOOR FIRE ALARM SYSTEM DESIGN



LEGEND

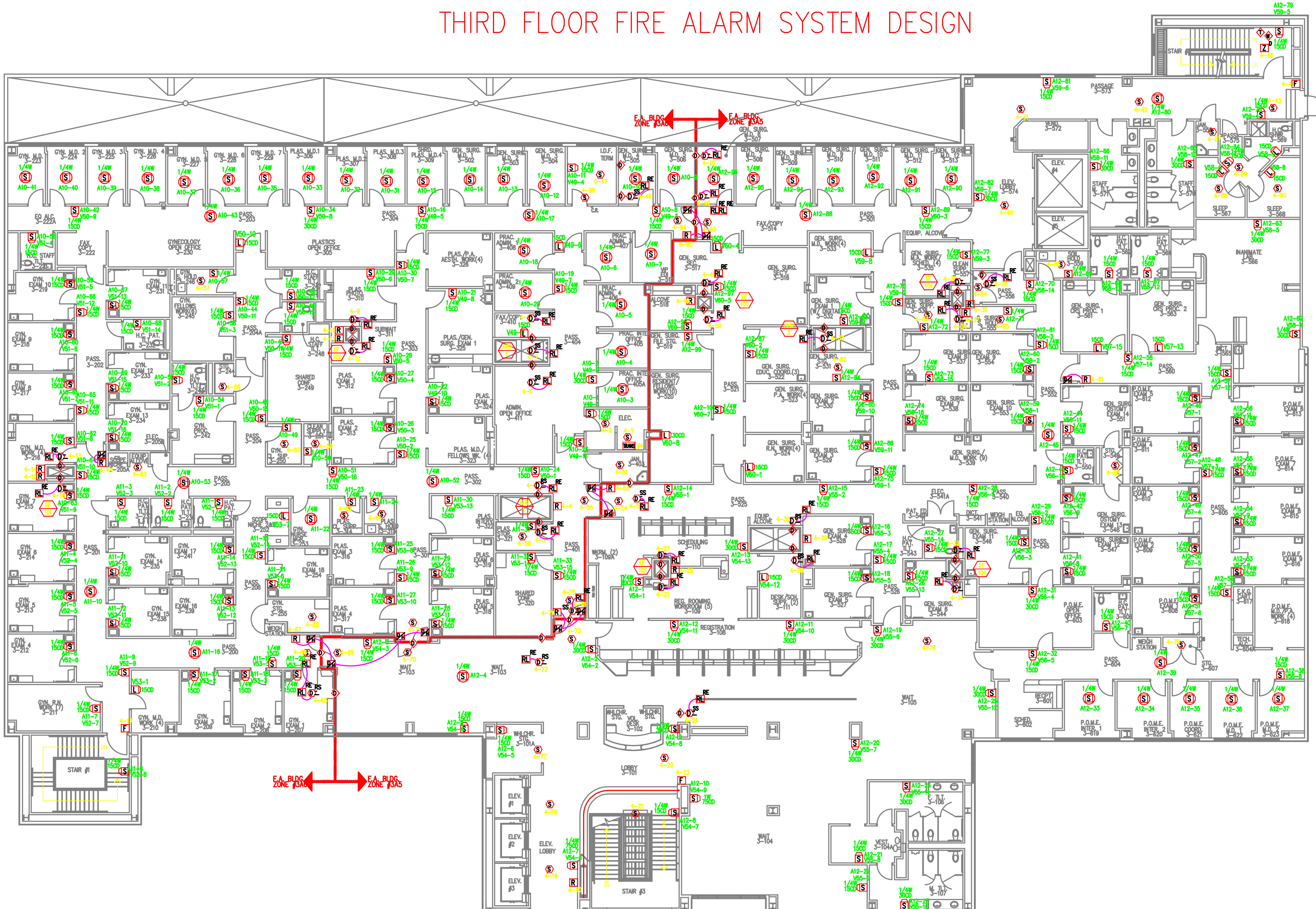
FACP	FIRE ALARM CONTROL PANEL
S	CEILING MOUNTED SMOKE DETECTOR
H E	CEILING MOUNTED THERMAL DETECTOR
D SS	DUCT DETECTOR HOUSING
RL RE	ROUND REMOTE ALARM INDICATING LAMP
F	MANUAL PULL STATION
Z	INTERFACE MODULE
R	INTERFACE MODULE WIRELAY
D/H	MAGNETIC DOOR HOLDER
L	WALL MOUNTED FIRE ALARM STROBE
S	SYNCHRONOUS FIRE ALARM SPEAKER/STROBE
S	WALL MOUNTED FIRE ALARM SPEAKER
S	CEILING MOUNTED FIRE ALARM SPEAKER
D	FIRE SMOKE DAMPER
W	WATER FLOW SWITCH
T	TAMPER SWITCH

SECOND FLOOR FIRE ALARM SYSTEM DESIGN



LEGEND	
FACP	FIRE ALARM CONTROL PANEL
S	CEILING MOUNTED SMOKE DETECTOR
H E	CEILING MOUNTED THERMAL DETECTOR
D SS	DUCT DETECTOR HOUSING
RL RE	ROUND REMOTE ALARM INDICATING LAMP
F	MANUAL PULL STATION
Z	INTERFACE MODULE
R	INTERFACE MODULE WIRELAY
DH	MAGNETIC DOOR HOLDER
L	WALL MOUNTED FIRE ALARM STROBE
S	SYNCHRONOUS FIRE ALARM SPEAKER/STROBE
S	WALL MOUNTED FIRE ALARM SPEAKER
S	CEILING MOUNTED FIRE ALARM SPEAKER
D	FIRE SMOKE DAMPER
W	WATER FLOW SWITCH
T	TAMPER SWITCH

THIRD FLOOR FIRE ALARM SYSTEM DESIGN



LEGEND	
FACP	FIRE ALARM CONTROL PANEL
S	CEILING MOUNTED SMOKE DETECTOR
H E	CEILING MOUNTED THERMAL DETECTOR
D SS	DUCT DETECTOR HOUSING
RL RE	ROUND REMOTE ALARM INDICATING LAMP
F	MANUAL PULL STATION
Z	INTERFACE MODULE
R	INTERFACE MODULE W/RELAY
	MAGNETIC DOOR HOLDER
L	WALL MOUNTED FIRE ALARM STROBE
S	SYNCHRONOUS FIRE ALARM SPEAKER/STROBE
S	WALL MOUNTED FIRE ALARM SPEAKER
S	CEILING MOUNTED FIRE ALARM SPEAKER
D	FIRE SMOKE DAMPER
W	WATER FLOW SWITCH
T	TAMPER SWITCH

Appendix I

ZIC-4A#1 - XLS Panel #1 Concourse					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #1					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	4		0	63	252
S-HP-MCS 30/75 CD	2		0	84	168
S-HP-MCS 75 CD	4		0	143	572
VISUAL CIRCUIT #2					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	2		0	63	126
S-HP-MCS 15/75 CD	7		0	63	441
S-HP-MCS 30/75 CD	3		0	84	252
S-HP-C-MCS 110 CD	1		0	178	178
VISUAL CIRCUIT #3					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	7		0	63	441
S-HP-MCS 30/75 CD	3		0	84	252
S-HP-MCS 75 CD	2		0	143	286
VISUAL CIRCUIT #4					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	2		0	63	126
S-HP-MCS 15/75 CD	7		0	63	441
S-HP-MCS 30/75 CD	1		0	84	84
S-HP-MCS 110 CD	1		0	178	178

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #1				
384	14ga	0.00307	1.004	2.37
VISUAL CIRCUIT #2				
562	14ga	0.00307	1.009	3.48
VISUAL CIRCUIT #3				
582	14ga	0.00307	1.054	3.77
VISUAL CIRCUIT #4				
640	14ga	0.00307	0.841	3.30

ZIC-4A#2 - XLS Panel #1 Concourse					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #5					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	3		0	63	189
S-HP-MCS 15/75 CD	5		0	63	315
S-HP-MCS 30/75 CD	3		0	84	252
S-HP-MCS 75 CD	1		0	143	143
VISUAL CIRCUIT #6					
End of Line Device	1	12	12	12	12
U-MCS 75 CD	1		0	143	143
S-HP-MCS 75 CD	5		0	143	715
VISUAL CIRCUIT #7					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	8		0	63	504
S-HP-MCS 30/75 CD	3		0	84	252
S-HP-C-MCS 15/75 CD	1		0	63	63
VISUAL CIRCUIT #8					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	7		0	63	441
S-HP-MCS 30/75 CD	1		0	84	84
S-HP-C-MCS 30/75 CD	1		0	84	84

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #5				
679	14ga	0.00307	0.911	3.80
VISUAL CIRCUIT #6				
720	14ga	0.00307	0.87	3.85
VISUAL CIRCUIT #7				
700	14ga	0.00307	0.894	3.84
VISUAL CIRCUIT #8				
612	14ga	0.00307	0.621	2.33

ZIC-4A#3 - XLS Panel #1 Concourse					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #9					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	14		0	63	882
VISUAL CIRCUIT #10					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	2		0	63	126
U-MCS 75 CD	1		0	143	143
S-HP-MCS 15/75 CD	5		0	63	315
VISUAL CIRCUIT #11					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	7		0	63	441
VISUAL CIRCUIT #12					
End of Line Device	1	12	12	12	12
S-HP-MCS 75 CD	4		0	143	572

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #9				
670	14ga	0.00307	0.894	3.68
VISUAL CIRCUIT #10				
576	14ga	0.00307	0.596	2.11
VISUAL CIRCUIT #11				
468	14ga	0.00307	0.453	1.30
VISUAL CIRCUIT #12				
724	14ga	0.00307	0.584	2.60

ZIC-4A#4 - XLS Panel #1 Concourse					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #13					
End of Line Device	1	12	12	12	12
S-HP-MCS 75 CD	4		0	143	572
VISUAL CIRCUIT #14					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	3		0	63	189
S-HP-MCS 75 CD	3		0	143	429
VISUAL CIRCUIT #15					
End of Line Device	1	12	12	12	12
VISUAL CIRCUIT #16					
End of Line Device	1	12	12	12	12

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #13				
644	14ga	0.00307	0.584	2.31
VISUAL CIRCUIT #14				
300	14ga	0.00307	0.63	1.16

XLS Voice Fire Alarm Control Panel - Concourse					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
PMI	1	230	230	230	230
SCM-B	2	14	28	14	28
DAC-NET	1	230	230	230	230
ZAC-40	3	150	450	150	450
PMI	1	230	230	230	230
DLC	2	145	290	327	654
NIC-C	1	120	120	120	120
RPM	1	150	150	150	150
ZIC-4A#1	1	48	48	3908	3908
ZIC-4A#2	1	48	48	3296	3296
ZIC-4A#3	1	48	48	2527	2527
ZIC-4A#4	1	48	48	1238	1238
SSD	2	200	400	200	400

Total Standby mA	2320	Total Alarm mA	13461
Convert to Amps	x0.001	Convert to Amps	x0.001
Total Standby Amps	2.32	Total Alarm Amps	13.461
Multiply by Hours	x24	Amp Hours for 15mins	x15/60
Total Standby Amp Hours	55.68	Total Alarm Hours	3.36525
		Total Standby Amp Hours	55.68
		Total Amp Hours	59.045
		Efficiency Factor	x1.2
		Required Amp Hours	**70.85**

ZIC-4A#6 - XLS Panel #2 First Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #17					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	10		0	63	630
S-HP-MCS 30/75 CD	2		0	84	168
S-HP-MCS 75 CD	1		0	143	143
S-HP-MCS 15/75 CD	1		0	63	63
VISUAL CIRCUIT #18					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	11		0	63	693
S-HP-MCS 30/75 CD	4		0	84	336
S-HP-MCS 110 CD	1		0	178	178
VISUAL CIRCUIT #19					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	10		0	63	630
S-HP-MCS 30/75 CD	2		0	84	168
VISUAL CIRCUIT #20					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	12		0	63	756

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #17				
524	14ga	0.00307	1.079	3.47
VISUAL CIRCUIT #18				
468	14ga	0.00307	1.219	3.50
VISUAL CIRCUIT #19				
470	14ga	0.00307	0.81	2.34
VISUAL CIRCUIT #20				
460	14ga	0.00307	0.831	2.35

ZIC-4A#7 - XLS Panel #2 First Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #21					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	10		0	63	630
S-HP-MCS 30/75 CD	1		0	84	84
VISUAL CIRCUIT #22					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	9		0	63	567
VISUAL CIRCUIT #23					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	16		0	63	1008
VISUAL CIRCUIT #24					
End of Line Device	1	12	12	12	12
S-HP-MCS 30/75 CD	7		0	84	588
S-HP-MCS 75 CD	4		0	143	572
Length x 2 x Resistance x Current = Voltage Drop					
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop	
VISUAL CIRCUIT #21					
284	14ga	0.00307	0.726	1.27	
VISUAL CIRCUIT #22					
318	14ga	0.00307	0.579	1.13	
VISUAL CIRCUIT #23					
482	14ga	0.00307	1.02	3.02	
VISUAL CIRCUIT #24					
440	14ga	0.00307	1.172	3.17	

ZIC-4A#8 - XLS Panel #2 First Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #25					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	8		0	63	504
S-HP-MCS 30/75 CD	5		0	84	420
VISUAL CIRCUIT #26					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	3		0	63	189
S-HP-MCS 15/75 CD	8		0	63	504
S-HP-MCS 30/75 CD	2		0	84	168
VISUAL CIRCUIT #27					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	4		0	63	252
S-HP-MCS 15/75 CD	5		0	63	315
S-HP-MCS 30/75 CD	2		0	84	168
S-HP-C-MCS 15/75 CD	4		0	63	252
VISUAL CIRCUIT #28					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	9		0	63	567
S-HP-MCS 30/75 CD	2		0	84	168

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #25				
508	14ga	0.00307	0.936	2.92
VISUAL CIRCUIT #26				
484	14ga	0.00307	0.873	2.59
VISUAL CIRCUIT #27				
592	14ga	0.00307	0.999	3.63
VISUAL CIRCUIT #28				
494	14ga	0.00307	0.747	2.27

ZIC-4A#9 - XLS Panel #2 First Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #29					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	13		0	63	819
S-HP-MCS 30/75 CD	1		0	84	84
VISUAL CIRCUIT #30					
End of Line Device	1	12	12	12	12
VISUAL CIRCUIT #31					
End of Line Device	1	12	12	12	12
VISUAL CIRCUIT #32					
End of Line Device	1	12	12	12	12
Length x 2 x Resistance x Current = Voltage Drop					
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop	
VISUAL CIRCUIT #29					
556	14ga	0.00307	0.915	3.12	

XLS Voice Fire Alarm Control Panel - First Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
DAC-NET	1	230	230	230	230
ZAC-40	3	150	450	150	450
PMI	1	230	230	230	230
NIC-C	1	120	120	120	120
ZIC-4A#6	1	48	48	3939	3939
ZIC-4A#7	1	48	48	3497	3497
ZIC-4A#8	1	48	48	3555	3555
ZIC-4A#9	1	48	48	951	951
SSD	2	200	400	200	400
Total Standby mA			1622	Total Alarm mA	13372
Convert to Amps			x0.001	Convert to Amps	x0.001
Total Standby Amps			1.622	Total Alarm Amps	13.372
Multiply by Hours			x24	Amp Hours for 15mins	x15/60
Total Standby Amp Hours			38.928	Total Alarm Hours	3.343
				Total Standby Amp Hours	38.928
				Total Amp Hours	42.271
				Efficiency Factor	x1.2
				Required Amp Hours	**50.73**

ZIC-4A#10 - XLS Panel #3 Second Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #33					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	16		0	63	1008
S-HP-MCS 30/75 CD	1		0	84	84
VISUAL CIRCUIT #34					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	17		0	63	1071
S-HP-MCS 30/75 CD	1		0	84	84
VISUAL CIRCUIT #35					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	10		0	63	630
S-HP-MCS 30/75 CD	5		0	84	420
VISUAL CIRCUIT #36					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	15		0	63	945
Length x 2 x Resistance x Current = Voltage Drop					
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop	
VISUAL CIRCUIT #33					
388	14ga	0.00307	1.104	2.63	
VISUAL CIRCUIT #34					
432	14ga	0.00307	1.23	3.26	
VISUAL CIRCUIT #35					
546	14ga	0.00307	1.125	3.77	
VISUAL CIRCUIT #36					
564	14ga	0.00307	1.02	3.53	

ZIC-4A#11 - XLS Panel #3 Second Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #37					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	11		0	63	693
VISUAL CIRCUIT #38					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	5		0	63	315
S-HP-MCS 15/75 CD	13		0	63	819
S-HP-MCS 30/75 CD	2		0	84	168
VISUAL CIRCUIT #39					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	12		0	63	756
S-HP-MCS 30/75 CD	2		0	84	168
VISUAL CIRCUIT #40					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	3		0	63	189
S-HP-MCS 30/75 CD	6		0	84	504
S-HP-MCS 75 CD	2		0	143	286

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #37				
542	14ga	0.00307	0.705	2.35
VISUAL CIRCUIT #38				
430	14ga	0.00307	1.314	3.47
VISUAL CIRCUIT #39				
500	14ga	0.00307	0.936	2.87
VISUAL CIRCUIT #40				
483	14ga	0.00307	0.991	2.94

ZIC-4A#12 - XLS Panel #3 Second Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #41					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	11		0	63	693
S-HP-MCS 30/75 CD	3		0	84	252
VISUAL CIRCUIT #42					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	9		0	63	567
S-HP-MCS 30/75 CD	5		0	84	420
VISUAL CIRCUIT #43					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	11		0	63	693
S-HP-MCS 30/75 CD	1		0	84	84
S-HP-MCS 75 CD	1		0	143	143
VISUAL CIRCUIT #44					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	12		0	63	756
S-HP-MCS 75 CD	1		0	143	143

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #41				
446	14ga	0.00307	0.957	2.62
VISUAL CIRCUIT #42				
502	14ga	0.00307	1.062	3.27
VISUAL CIRCUIT #43				
532	14ga	0.00307	0.932	3.04
VISUAL CIRCUIT #44				
498	14ga	0.00307	0.911	2.79

ZIC-4A#13 - XLS Panel #3 Second Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #45					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	12		0	63	756
S-HP-MCS 30/75 CD	2		0	84	168
VISUAL CIRCUIT #46					
End of Line Device	1	12	12	12	12
VISUAL CIRCUIT #47					
End of Line Device	1	12	12	12	12
VISUAL CIRCUIT #48					
End of Line Device	1	12	12	12	12
Length x 2 x Resistance x Current = Voltage Drop					
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop	
VISUAL CIRCUIT #45					
558	14ga	0.00307	0.936	3.21	

XLS Voice Fire Alarm Control Panel - Second Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
DAC-NET	1	230	230	230	230
ZAC-40	2	150	300	150	300
DLC	2	145	290	370	740
NIC-C	1	120	120	120	120
ZIC-4A#10	1	48	48	4479	4479
ZIC-4A#11	1	48	48	3946	3946
ZIC-4A#12	1	48	48	3862	3862
ZIC-4A#13	1	48	48	972	972

Total Standby mA	1132	Total Alarm mA	14649
Convert to Amps	x0.001	Convert to Amps	x0.001
Total Standby Amps	1.132	Total Alarm Amps	14.649
Multiply by Hours	x24	Amp Hours for 15mins	x15/60
Total Standby Amp Hours	27.168	Total Alarm Hours	3.66225
		Total Standby Amp Hours	27.168
		Total Amp Hours	30.83025
		Efficiency Factor	x1.2
		Required Amp Hours	**37.00**

ZIC-4A#14 - XLS Panel #4 Third Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #49					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	2		0	63	126
S-HP-MCS 15/75 CD	8		0	63	504
S-HP-MCS 30/75 CD	1		0	84	84
VISUAL CIRCUIT #50					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	14		0	63	882
S-HP-MCS 30/75 CD	1		0	84	84
S-HP-C-MCS 15/75 CD	1		0	63	63
VISUAL CIRCUIT #51					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	16		0	63	1008
VISUAL CIRCUIT #52					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	14		0	63	882

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #49				
420	14ga	0.00307	0.726	1.87
VISUAL CIRCUIT #50				
486	14ga	0.00307	1.041	3.11
VISUAL CIRCUIT #51				
542	14ga	0.00307	1.02	3.39
VISUAL CIRCUIT #52				
480	14ga	0.00307	0.894	2.63

ZIC-4A#15 - XLS Panel #4 Third Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #53					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	2		0	63	126
S-HP-MCS 15/75 CD	14		0	63	882
VISUAL CIRCUIT #54					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	4		0	63	252
S-HP-MCS 30/75 CD	6		0	84	504
S-HP-MCS 75 CD	2		0	143	286
VISUAL CIRCUIT #55					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	9		0	63	567
S-HP-MCS 30/75 CD	5		0	84	420
VISUAL CIRCUIT #56					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	10		0	63	630
S-HP-MCS 30/75 CD	1		0	84	84

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #53				
520	14ga	0.00307	1.02	3.26
VISUAL CIRCUIT #54				
540	14ga	0.00307	1.117	3.70
VISUAL CIRCUIT #55				
388	14ga	0.00307	0.999	2.38
VISUAL CIRCUIT #56				
470	14ga	0.00307	0.726	2.10

ZIC-4A#16 - XLS Panel #4 Third Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #57					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	2		0	63	126
S-HP-MCS 15/75 CD	13		0	63	819
VISUAL CIRCUIT #58					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	0		0	63	0
S-HP-MCS 15/75 CD	12		0	63	756
S-HP-MCS 30/75 CD	4		0	84	336
VISUAL CIRCUIT #59					
End of Line Device	1	12	12	12	12
U-MCS 15/75 CD	1		0	63	63
S-HP-MCS 15/75 CD	9		0	63	567
S-HP-MCS 30/75 CD	1		0	84	84
VISUAL CIRCUIT #60					
End of Line Device	1	12	12	12	12

Length x 2 x Resistance x Current = Voltage Drop				
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop
VISUAL CIRCUIT #57				
494	14ga	0.00307	0.957	2.90
VISUAL CIRCUIT #58				
536	14ga	0.00307	1.104	3.63
VISUAL CIRCUIT #59				
566	14ga	0.00307	0.726	2.52
VISUAL CIRCUIT #60				
330	14ga	0.00307	0.012	0.02

ZIC-4A#17 - XLS Panel #4 Third Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
VISUAL CIRCUIT #61					
End of Line Device	1	12	12	12	12
S-HP-MCS 30/75 CD	2		0	84	168
S-HP-MCS 75 CD	5		0	143	715
S-HP-MCS 110 CD	1		0	178	178
VISUAL CIRCUIT #62					
End of Line Device	1	12	12	12	12
S-HP-MCS 75 CD	3		0	143	429
S-HP-MCS 110 CD	2		0	178	356
VISUAL CIRCUIT #63					
End of Line Device	1	12	12	12	12
S-HP-MCS 75 CD	2		0	143	286
S-HP-MCS 110 CD	1		0	178	178
VISUAL CIRCUIT #64					
End of Line Device	1	12	12	12	12
S-HP-MCS 15/75 CD	3		0	63	189
Length x 2 x Resistance x Current = Voltage Drop					
Cable Length	Cable Size	Cable Resistance	Current	Voltage Drop	
VISUAL CIRCUIT #61					
486	14ga	0.00307	1.073	3.20	
VISUAL CIRCUIT #62					
412	14ga	0.00307	0.797	2.02	
VISUAL CIRCUIT #63					
436	14ga	0.00307	0.476	1.27	
VISUAL CIRCUIT #64					
660	14ga	0.00307	0.201	0.81	

XLS Voice Fire Alarm Control Panel - Third Floor					
Module/Device	Quantity	Standby mA per unit	Total Standby	Alarm mA per unit	Total Alarm
DAC-NET	1	230	230	230	230
ZAC-40	4	150	600	150	600
NIC-C	1	120	120	120	120
ZIC-4A#14	1	48	48	3681	3681
ZIC-4A#15	1	48	48	3862	3862
ZIC-4A#16	1	48	48	2799	2799
ZIC-4A#17	1	48	48	2547	2547

Total Standby mA	1142	Total Alarm mA	13839
Convert to Amps	x0.001	Convert to Amps	x0.001
Total Standby Amps	1.142	Total Alarm Amps	13.839
Multiply by Hours	x24	Amp Hours for 15mins	x15/60
Total Standby Amp Hours	27.408	Total Alarm Hours	3.45975
		Total Standby Amp Hours	27.408
		Total Amp Hours	30.86775
		Efficiency Factor	x1.2
		Required Amp Hours	**37.04**

Appendix J

Mayo Employee Training

All staff in Mayo Campus clinical buildings receive the following training:

1) Location of pull stations, fire extinguishers, and exits.

2) Emergency telephone numbers.

3) R-A-C-E Procedure: Relocate / Rescue those in immediate danger; Activate (pull station and emergency phone number); Contain; Extinguish if safe to do so.

4) Proper use a fire extinguisher: P-A-S-S [Pull, Aim, Squeeze and Sweep].

5) Location of exit pathways and the importance of keeping them free of obstructions.

6) Management of oxygen zone valves.

Security, Facilities, Administrators on Call / Incident Commanders:

Trained as noted above, plus their specific roles and responsibilities.

Additional Info

Drills are conducted quarterly - locations vary and both "at the scene" and "away from the scene" areas are observed. Feedback is provided at the time of the drill and also sent to managers to review with staff.

Training occurs upon orientation and annually thereafter.

Plans specific to a particular facility are developed prior to occupancy and all staff are trained.

Life (Fire) Safety Management Plan (9400)

Content Applies To:

Mayo Clinic Arizona

Scope

The Environmental Safety and Procedure Manual applies to all Consultant and Allied Health Staff employees in Mayo Clinic Arizona.

Purpose

To outline the components of the life (fire) safety management program.

Procedure

Mayo Clinic in Arizona (including the Scottsdale, Phoenix, Arrowhead and Thunderbird campuses) will maintain an active and ongoing Life Safety Management Program, which is designed, implemented and evaluated in a planned and coordinated manner to accomplish the following goals:

1. Protection of patients, employees, visitors and property from fire, smoke, and other products of combustion. Mayo facilities are designed and built using all applicable life safety guidelines/ requirements, including but not limited to Guidelines for Design and Construction of Hospital and Health Care Facilities and applicable local and state rules and regulations. In addition, an Interim Life Safety Procedure is implemented, as appropriate, when there are significant interruptions of life safety systems within an occupied facility.

2. Inspection, testing and maintenance of fire protection and life safety systems, equipment, and components on a regular basis. Facilities Engineering assumes responsibility for completion/coordination of these inspections, testing, and maintenance.
   a. This testing includes supervisory signal devices, water-flow devices/systems, duct detectors, electromagnetic releasing devices, heat detectors, fire alarm pull stations, smoke detectors, portable extinguishers, fire and smoke dampers and other related equipment.

3. Development of a fire response plan that addresses facility-wide response; area specific needs; specific roles and responsibilities of staff, licensed independent practitioners and volunteers at and away from the fires point of origin; and building evacuation. Refer to Fire and Evacuation Plans. In addition, special department needs are identified in work area-specific plans as needed.
   a. Fire response plans will be exercised quarterly on each shift in each building defined as a health care occupancy by the Life Safety Code.
   b. The fire response plan will be exercised quarterly in each building defined as an ambulatory health care or a business occupancy in which patients are seen or treated.

4. Review of proposed acquisitions of bedding, window draperies, and other curtains, furnishings and decorations, wastebaskets, and other equipment for fire safety. Supply Chain Management, in consultation with Campus and Facilities Management reviews all purchases to ensure they meet the appropriate fire ratings.

5. Provisions for the protection of occupants during periods of renovation or construction. Refer to the Interim Life Safety procedure.

6. Establishment of a life safety orientation and education program that addresses specific roles and responsibilities of employees, physicians and other licensed independent practitioners at and away from a fire's point of origin and in preparing for building evacuation, use and functioning of fire alarm systems and building compartmentalization. Education occurs at both a central and department level. Refer to "Primary Responsibilities" section.

7. Completion of on-going monitoring of performance.
   a. The Performance Measures for this management plan are:
      i. % of electrical and mechanical rooms with combustible items and/or items found within the 3 foot minimum clearance around electrical panels (based on observation during routine safety reviews).
      ii. % of egress corridors which are free of obstructions.
   b. Quarterly Reports

      Quarterly Reports reviewing the status of the above noted performance management indicators will be submitted on a quarterly basis to the CPC Environmental Health, Safety and Security (EHSS) Subcommittee. These reports will include the following information: Performance Measure/Goal; Baseline Threshold; Results/Summary; Recommendations; Plan of Action; and Person(s) Responsible.

8. Evaluation of the Life Safety Management Program on an annual basis. This evaluation, with goals for the coming year, will be forwarded to the EHSS Subcommittee for review, input and approval.

The Life Safety Management Program will address the above noted goals as they relate to patients, employees, physicians, visitors, and the community.

Mayo Clinic Arizona Executive Operations Team

Identified life safety management issues and summaries of activities will be communicated periodically to the Executive Operations Team through the Clinical Practice Committee and the Chairman of the EHSS Subcommittee.

Administration

Administration will support the efforts of the Life Safety Management Program to all management staff.

Medical Staff

The Medical Staff, through its Clinical Practice Committee, will:

1. Participate in the identification of potential risks in the clinical aspects of patient care and safety.

2. Assist in the correction of associated problems and the design of programs to reduce risks.

Operations Administrator / Safety Officer
Chair of Campus and Facilities Management

The Mayo Arizona Safety Officer and the Chair of Campus and Facilities Management (designees) will share the responsibility for the overall coordination of the Life Safety Management Program. They will:

1. Provide and oversee orientation and continuing education programs for all employees as it relates to life safety.
2. Serve as a consultant/advisor to management.
3. Ensure compliance with life safety-related standards from the various regulatory agencies.
4. Maintain a liaison with the EHSS Subcommittee.
5. Prepare appropriate life safety management reports, including an annual evaluation of the Life Safety Management Program in relation to established goals and objectives.

Management

Managers are responsible for supporting the goals and objectives of the Life Safety Management Program. Managers will:

1. Ensure employees participate in life safety programs/activities, both central and work area specific (e.g. orientation, continuing education, fire and evacuation drills, etc.).

2. Identify and correct hazardous life safety conditions within their work area.

3. Report life safety hazards/potential hazards within the system to the Environmental Safety Office or any member of the EHSS Subcommittee.

4. Complete various life safety reports as requested.

5. Develop, as appropriate, and review, at least every three (3) years, work area specific life safety policies and procedures.

Employees

All employees are responsible for supporting the Life Safety Management Program. Employees will:

1. Know and follow both system-wide and work area specific life safety policies and procedures.

2. Report and correct, when possible, actual/potential life safety hazards.

3. Attend appropriate required educational programs.

CPC Environmental Health, Safety and Security (EHSS) Subcommittee

The EHSS Subcommittee is responsible for providing oversight for the development, implementation, maintenance, and evaluation of a comprehensive Life Safety Management Program for Mayo Clinic Arizona. This includes the responsibility for review and approval of all life safety related policies and procedures.

Appendix K

CONCOURSE FLOOR						
RM#	NAME	#EXITS	#DOORS	OCC. LOAD	EXIT CAP. FACTOR	EXIT CAP.
EAST OF HORIZONTAL EXIT						
C-208	EMERG. SWGR. ROOM	1	1	1	0.15	240
C-207	PLUMB. RM.	1	1	1	0.15	240
C-224	SHOP ROOM	2	1	1	0.15	240
C-209	MAIN ELEC.	1	3	3	0.15	720
C-301	CONFERENCE	1	2	43	0.15	480
C-302	CONFERENCE	1	2	43	0.15	480
C-302A	CONFERENCE	1	1	43	0.15	240
C-304A	STORAGE	1	1	1	0.15	240
C-205	STG.	1	2	0	0.15	480
C-210	UPS ROOM	1	1	1	0.15	240
C-202	PNEU. TUBE	1	1	6	0.15	240
C-192	ACCELERATOR	1	1	2	0.15	240
C-191	ACCELERATOR	1	1	2	0.15	240
C-159	ACCELERATOR	1	1	2	0.15	240
C-153	ACCELERATOR	1	1	2	0.15	240
C-202A	LKRS.	1	1	2	0.15	240
C-201	OFFICE	1	1	1	0.15	240
C-201A	OPEN OFFICE	1	1	7	0.15	240
C-201B	FUTURE OFFICE	1	1	2	0.15	240
C-202B	HC. TLT.	1	1		0.15	240
C-204	JAN.	1	1	0	0.15	240
C-197	STORAGE	1	1	1	0.15	240
C-203	CONFERENCE	1	1	24	0.15	240
C-203A	CONFERENCE	1	1	24	0.15	240
C-206	CONFERENCE	2	2	34	0.15	480
C-195	CONT.	1	1	22	0.15	240
C-194	C.T. SIMULATOR	1	1	5	0.15	240
C-313	STOR.	1	1	0	0.15	240
C-314	M.D. 7	1	1	1	0.15	240
C-198	STG.	1	1	1	0.15	240
C-199A	H.C. TLT.	1	1		0.15	240
C-315	STOR.	1	1	1	0.15	240
C-196	I.D.F. TERM	1	1	2	0.15	240
C-188	MODUL	1	1	2	0.15	240
C-185, C	DRESSING ROOMS	1	1	4	0.15	240
C-184	H.C. TLT.	1	1		0.15	240
C-222	BLOCK ROOM	1	1	3	0.15	240
C-170	DOSIMETRY	2	2	3	0.15	480
C-161, C	CONT.	3	3	4	0.15	720
C-162	VIEW	2	2	2	0.15	480
C-163	DK. RM.	1	1	1	0.15	240
C-220, C	INFUSION AND NURSE WK.	1	1	6	0.15	240
C-156	PAT. TLT.	1	1		0.15	240
C-171	ELEC.	1	1	0	0.15	240

C-312	M.D. 6	1	1	1	0.15	240
C-311	M.D. 5	1	1	1	0.15	240
C-310	M.D. 4	1	1	1	0.15	240
C-309	M.D. 3	1	1	1	0.15	240
C-308	M.D. 2	1	1	1	0.15	240
C-307	M.D. 1	1	1	1	0.15	240
C-212	COURTYARD	3	4	16	0.15	960
C-133A	JAN.	1	1	0	0.15	240
C-128	EX. 13	1	1	1	0.15	240
C-124	EX. 12	1	1	2	0.15	240
C-146	EX. 11	1	1	1	0.15	240
C-147	EX. 10	1	1	2	0.15	240
C-130	PHYSICS LAB	1	1	3	0.15	240
C-127	EX. 14	1	1	1	0.15	240
C-125	EX. 13	1	1	2	0.15	240
C-123	WORK	1	1	1	0.15	240
C-119	EX. 8	1	1	2	0.15	240
C-149	EX. 7	1	1	1	0.15	240
C-148	MID LEVEL WORK ROOM	1	1	2	0.15	240
C-122	HC. TLT.	1	1		0.15	240
C-216, C	DRESSING ROOMS	1	1	5	0.15	240
C-181	PAT. TLT	1	1		0.15	240
C-168	MGR. OFF.	1	1	1	0.15	240
C-167	LNGE.	1	1	17	0.15	240
C-166	STAFF TLT.	1	1		0.15	240
C-164	CONF. RM.	1	1	27	0.15	240
C-152	NURSE WK.	1	1	3	0.15	240
C-151	M.D. WORK	1	1	2	0.15	240
C-120	EX. 9	1	1	2	0.15	240
C-110	EX. 1	1	1	1	0.15	240
C-112	EX. 2	1	1	2	0.15	240
C-113	EX. 3	1	1	1	0.15	240
C-114	EX. 4	1	1	2	0.15	240
C-115	H.C. TLT.	1	1		0.15	240
C-116	EX.5	1	1	1	0.15	240
C-117	EX. 6	1	1	2	0.15	240
C-107	F. TLT.	1	1		0.15	240
C-106	M. TLT.	1	1		0.15	240
C-102	RECPT.	1	1	3	0.15	240
C-109	COUNSEL	1	1	2	0.15	240
C-108, C	PAT. EDUC.	1	1	2	0.15	240
C-103, C	WAIT, LOBBY, ELEV LOBBY	3	3	127	0.15	720
C-211	STAIRWAY#1	1	1		0.2	220
NUM	HORIZONTAL EXIT DOORS	4	4		0.15	960
WEST OF HORIZONTAL EXIT						
C-304	F. TLT.	1	1		0.2	180
C-305	M. TLT.	1	1		0.2	180

C-132	HDR ROOM	1	1	5	0.2	180
C-131	HDR CONT	1	1	2	0.2	180
C-141	MODUL	1	1	2	0.2	180
C-129	SOIL HOLD	1	1	0	0.2	180
C-143	CLEAN SUPPLIES	1	1	0	0.2	180
C-143A	STG.	1	1	0	0.2	180
C-144	IN-PAT. HOLD	2	3	2	0.2	540
C-214	STAIRWAY#2	1	1		0.3	147
NUM	HORIZONTAL EXIT DOORS	3	3		0.2	540
NUM	WEST HORIZONTAL EXIT	1	1		0.2	240
EXITS FOR ENTIRE FLOOR						
C-211	STAIRWAY#1	1	1		0.2	220
C-214	STAIRWAY#2	1	1		0.3	147
NUM	WEST HORIZONTAL EXIT	1	1		0.2	240

OCC. LOAD EAST OF HORIZ. EXIT	**543**
EXIT CAP. EAST OF HORIZ. EXIT	**1180**
EAST- 50% REQ'D CAP.	**271.5**
EAST - 1 EXIT COMPROMISED CAPACITY	**960**
OCC. LOAD WEST OF HORIZ. EXIT	**11**
EXIT CAP. WEST OF HORIZ. EXIT	**927**
WEST - 50% REQ'D CAP.	**6**
WEST - 1 EXIT COMPROMISED CAPACITY	**687**
TOTAL OCC. LOAD	**541**
TOTAL FLOOR EXIT CAPACITY	**607**
FLOOR - 50% REQ'D CAP.	**271**
FLOOR - 1 EXIT COMPROMISED CAP.	**367**

FIRST FLOOR						
RM#	NAME	#EXITS	#DOORS	OCC. LOAD	EXIT CAP. FACTOR	EXIT CAP.
EAST OF HORIZONTAL EXIT						
1-263	TRANS./ID	2	2	8	0.15	480
1-265	TRANS./ID	2	2	6	0.15	480
1-266	TRANS./ID	2	2	5	0.15	480
1-267	TRANS./ID	3	3	8	0.15	720
1-268	TRANS./ID	2	2	5	0.15	480
1-250	TRANS. M.D. 7	1	1	1	0.15	240
1-251	TRANS. M.D. 8	1	1	1	0.15	240
1-252	TRANS. M.D. 9	1	1	1	0.15	240
1-253	TRANS. M.D. 10	1	1	1	0.15	240
1-255	TRANS. M.D. 11	1	1	1	0.15	240
1-256	TRANS. M.D. 12	1	1	1	0.15	240
1-257	TRANS. M.D. 13	1	1	1	0.15	240
1-258	TRANS. M.D. 14	1	1	1	0.15	240
1-259	ID MD 1	1	1	1	0.15	240
1-260	ID MD 2	1	1	1	0.15	240
1-261	ID MD 3	1	1	1	0.15	240
1-262	ID MD 4	1	1	1	0.15	240
1-328	CT MD 1	1	1	1	0.15	240
1-329 AN	CT MD 2	2	2	2	0.15	480
1-443	ENT MD 1	1	1	1	0.15	240
1-444	ENT MD 2	1	1	1	0.15	240
1-445	ENT MD 3	1	1	1	0.15	240
1-446	ENT MD 4	1	1	1	0.15	240
1-447	ENT MD 5	1	1	1	0.15	240
1-448	ENT MD 6	1	1	1	0.15	240
1-327A	COPY	1	1	1	0.15	240
1-449	ENT MD 7	1	1	1	0.15	240
1-451	BREAK ROOM	1	1	13	0.15	240
1-437	ENT PANOREX	1	1	2	0.15	240
1-453	ENT M.D. 8	1	1	1	0.15	240
1-452, 1-	ENT OPEN OFFICE, ENT RES WORK, DIC	2	3	7	0.15	720
1-424	CL. SUP.	1	1	0	0.15	240
1-435	ENT PROC. 3	1	1	1	0.15	240
1-432	ENT PA WORK	1	1	2	0.15	240
1-434	ENT PROC. 2	1	1	1	0.15	240
1-327	FAX/COPY	1	1	1	0.15	240
1-325	CT MD 3	1	1	1	0.15	240
1-324	CT MD 4	1	1	1	0.15	240
1-323	HRT. FAIL MD 2	1	1	1	0.15	240
1-440	VIDEO CONF	1	1	28	0.15	240
1-439	ENT PROC. 1	1	1	3	0.15	240
1-110	ELEC.	1	1	0	0.15	240
1-456A	CL. SUPP.	1	1	0	0.15	240

1-321	OPEN OFFICE	2	2	6	0.15	480
1-317	HRT. FAIL EXAM 3	1	1	2	0.15	240
1-316	CT SUPV 2	1	1	2	0.15	240
1-313	HRT. FAIL EXAM 2	1	1	2	0.15	240
1-314	EKG	1	1	2	0.15	240
1-244	TRANS. MD 3	1	1	1	0.15	240
1-243	TRANS. MD 2	1	1	1	0.15	240
1-242	TRANS. MD 1	1	1	1	0.15	240
1-241	SOCIAL WORKS	1	1	1	0.15	240
1-320	INT CARD. EXAM	1	1	2	0.15	240
1-240	FELLOWS	1	1	1	0.15	240
1-319	HC STAFF TLT.	1	1		0.15	240
1-239	TRANS/ID EXAM 18	1	1	2	0.15	240
1-312	HRT. FAIL EXAM 1	1	1	1	0.15	240
1-238	HC PAT TLT.	1	1		0.15	240
1-311	HC PAT TLT.	1	1		0.15	240
1-247	TRANS. MD 6	1	1	1	0.15	240
1-246	TRANS MD. 5	1	1	1	0.15	240
1-245	TRANS. MD. 4	1	1	1	0.15	240
1-226	TRANS/RESEARCH WORK	2	2	2	0.15	480
1-227	TRANS/RESEARCH RECORDS	2	2	2	0.15	480
1-225	HBC NP/RN WORK	1	1	2	0.15	240
1-228	TRANS/ID EXAM 11	1	1	2	0.15	240
1-224	TRANS/ID EXAM 10	1	1	2	0.15	240
1-229	TRANS/ID EXAM 12	1	1	2	0.15	240
1-248	TRANS-OPS. MGR.	1	1	1	0.15	240
1-218	FAX/COPY	2	2	1	0.15	480
1-217	TRANS/ID	1	1	1	0.15	240
1-216	TRANS/ID	1	1	2	0.15	240
1-213	HC STAFF TLT.	1	1		0.15	240
1-219B	ELEC.	1	1	0	0.15	240
1-215	TRANS/ID	1	1	1	0.15	240
1-214	TRANS/ID	1	1	1	0.15	240
1-212	TRANS/ID EXAM 6	1	1	2	0.15	240
1-211	TRANS/ID EXAM 5	1	1	1	0.15	240
1-210	TRANS/ID EXAM 4	1	1	2	0.15	240
1-209	TRANS/ID EXAM 3	1	1	1	0.15	240
1-208	TRANS/ID MD WORK	1	1	2	0.15	240
1-207	TRANS/ID EXAM 2	1	1	2	0.15	240
1-206	TRANS/ID EXAM 1	1	1	1	0.15	240
1-205	TRANS/ID PAT EDUC INTERVIEW	1	1	2	0.15	240
1-204	TRANS/ID INTERV. 1	1	1	1	0.15	240
1-203	TRANS/ID INTERV. 2	1	1	2	0.15	240
1-202	TRANS/ID INTERV. 3	1	1	1	0.15	240
1-223	TRANS/ID EXAM 9	1	1	2	0.15	240
1-231	TRANS/ID EXAM 13	1	1	1	0.15	240
1-222	TRANS/ID EXAM 8	1	1	2	0.15	240

1-232	TRANS/ID EXAM 14	1	1	1	0.15	240
1-221	TRANS/ID EXAM 7	1	1	2	0.15	240
1-233	TRANS/ID EXAM 15	1	1	1	0.15	240
1-237	TRANS/ID SURG MD WORK	1	1	2	0.15	240
1-305	CT EXAM 3	1	1	2	0.15	240
1-236	TRANS/ID EXAM 17	1	1	2	0.15	240
1-302	CT EXAM 2	1	1	2	0.15	240
1-235	TRANS/ID EXAM 16	1	1	2	0.15	240
1-301	CT EXAM 1	1	1	2	0.15	240
1-306	CT EXAM 4	1	1	2	0.15	240
1-304	CT/HF WORK	2	2	3	0.15	480
1-307	JAN.	1	1	0	0.15	240
1-117	FAX/COPY	2	2	1	0.15	480
1-309	CT/HF/RN WORK	1	1	2	0.15	240
1-106	F. TLT.	1	1		0.15	240
1-107	M. TLT.	1	1		0.15	240
1-101A	WHLCHR. STG.	1	1	1	0.15	240
1-101	LOBBY WAITING AREAS	6	9	278	0.15	2160
NUM	STAIRWAY#1	1	1		0.2	220
NUM	HORIZONTAL EXIT DOORS	7	7		0.15	1680
WEST OF HORIZONTAL EXIT						
1-461	VENDING			1	0.15	0
1-463	F. TLT.	1	1		0.15	240
1-464	M. TLT.	1	1		0.15	240
1-459, 1-	CENTRAL PROC.	2	2	5	0.15	480
1-455	DICT	1	1	1	0.15	240
1-457	S. HOLD	1	1	0	0.15	240
1-454	JAN.	1	1	0	0.15	240
1-425	ENT EXAM 14	1	1	2	0.15	240
1-420	ENT EXAM 9	1	1	2	0.15	240
1-417	ENT EXAM 8	1	1	1	0.15	240
1-413	ENT EXAM 1	1	1	2	0.15	240
1-423	ENT EXAM 13	1	1	2	0.15	240
1-419	ENT EXAM 10	1	1	2	0.15	240
1-416	ENT EXAM 7	1	1	1	0.15	240
1-412	ENT EXAM 2	1	1	1	0.15	240
1-422	ENT EXAM 12	1	1	2	0.15	240
1-418	ENT EXAM 11	1	1	2	0.15	240
1-415	ENT EXAM 6	1	1	1	0.15	240
1-411	ENT EXAM 3	1	1	2	0.15	240
1-410	ENT EXAM 4	1	1	1	0.15	240
1-401A,	AUDIOLOGY	1	1	3	0.15	240
1-404	ENT RN SUPV	1	1	1	0.15	240
1-402	OTOLOGY ENT EXAM 5	1	1	2	0.15	240
1-406	ENT MD. WK.	1	1	1	0.15	240
1-407	ENT RN WORK	1	1	2	0.15	240
1-408A	HC PAT TLT.	1	1		0.15	240

1-427	ENT EXAM 16	1	1	1	0.15	240
1-426	ENT EXAM 15	1	1	1	0.15	240
1-115	FIN COUNS OFFICE	1	1	1	0.15	240
1-113	FIN COUNS OFFICE	1	1	1	0.15	240
1-114	FIN COUNS OFFICE	1	1	1	0.15	240
1-431	ENT EXAM 17	1	1	2	0.15	240
1-118	PRE-CERT	1	1	2	0.15	240
1-120	PRE-CERT.	1	1	1	0.15	240
1-110, 1-	BACK REGISTRATION AREA	3	3	13	0.15	720
1-108	REGISTRATION	2	2	5	0.15	480
1-503	BLOOD DRAW	1	1	1	0.15	240
1-504	BLOOD DRAW	1	1	1	0.15	240
1-505	BLOOD DRAW	1	1	1	0.15	240
1-506	BLOOD DRAW	1	1	1	0.15	240
1-507	BLOOD DRAW	1	1	1	0.15	240
1-508	BLOOD DRAW	1	1	1	0.15	240
1-509	BLOOD DRAW	1	1	1	0.15	240
1-501, 1-	LAB WORK/PROC	2	2	7	0.15	480
1-510	LAB. STG.	1	1	0	0.15	240
1-514	HC PAT TLT.	1	1		0.15	240
1-513	HC PAT TLT.	1	1		0.15	240
1-512	HC PAT TLT.	1	1		0.15	240
1-123	PRE-CERT. SUPV.	1	1	1	0.15	240
1-119	INTERN.	1	1	2	0.15	240
1-121	PAL OFF.	2	2	2	0.15	480
NUM	STAIRWAY#2	1	1		0.2	220
NUM	MAIN BUILDING EXIT	4	4		0.15	1467
NUM	HORIZONTAL EXIT DOORS	6	6		0.15	1440
NUM	WEST HORIZONTAL EXIT	1	1		0.15	240
EXITS FOR ENTIRE FLOOR						
NUM	STAIRWAY#1	1	1		0.2	220
NUM	STAIRWAY#2	1	1		0.2	220
NUM	WEST HORIZONTAL EXIT	1	1		0.15	240

TOTAL OCC. LOAD EAST OF HORIZ. EXIT	**488**
TOTAL EXIT CAP. EAST OF HORIZ. EXIT	**1900**
EAST - 50% REQ'D CAP.	**244**
EAST - 1 EXIT COMPROMISED CAP.	**1680**
TOTAL OCC. LOAD WEST OF HORIZ. EXIT	**84**
TOTAL EXIT CAP. WEST OF HORIZ. EXIT	**3367**
WEST - 50% REQ'D CAP.	**42**
WEST - 1 EXIT COMPROMISED CAP.	**1900**
TOTAL OCC. LOAD	**572**
TOTAL FLOOR EXIT CAPACITY	**680**
FLOOR - 50% REQ'D CAP.	**286**
FLOOR - 1 EXIT COMPROMISED CAP.	**440**

SECOND FLOOR						
RM#	NAME	#EXITS	#DOORS	OCC. LOAD	EXIT CAP. FACTOR	EXIT CAP.
EAST OF HORIZONTAL EXIT						
2-264	UROLOGY OPEN OFFICE	1	1	5	0.15	240
2-269	UROL. RES. FELLOWS	1	1	6	0.15	240
2-384	ORTHO. FELLOWS	2	2	6	0.15	480
2-375A	RESEARCH	2	2	5	0.15	480
2-375	ORTHO. OPEN OFFICE	2	2	3	0.15	480
2-370	SHARED CONF	1	1	22	0.15	240
2-367	ORTHO. MD. 11	1	1	1	0.15	240
2-372	ORTHO. MD. 8	1	1	1	0.15	240
2-369	ORTHO. MD. 9	1	1	1	0.15	240
2-368	ORTHO. MD 10	1	1	1	0.15	240
NUM	IDF TERM	1	1	1	0.15	240
2-374	ORTHO. MD. 6	1	1	1	0.15	240
2-373	ORTHO. MD. 7	1	1	1	0.15	240
2-380	ORTHO. MD. 3	1	1	1	0.15	240
2-379	ORTHO. MD. 4	1	1	1	0.15	240
2-376	ORTHO. MD. 5	1	1	1	0.15	240
2-260	SHARED UROL. MD. 8	1	1	1	0.15	240
2-382	ORTHO. MD. 1	1	1	1	0.15	240
2-381	ORTHO. MD. 2	1	1	1	0.15	240
2-265	UROL. MD. 5	1	1	1	0.15	240
2-263	UROL. MD. 5	1	1	1	0.15	240
2-262	UROL. MD. 7	1	1	1	0.15	240
2-268	UROL. MD. 3	1	1	1	0.15	240
2-266	UROL. MD. 4	1	1	1	0.15	240
2-271	UROL. MD 1	1	1	1	0.15	240
2-270	UROL. MD. 2	1	1	1	0.15	240
2-255	HC PAT. TLT.	1	1		0.15	240
2-257	UROL. PA/RN SUPV	1	1	1	0.15	240
2-258	UROL. PA WORK	1	1	2	0.15	240
2-321	HAND EXAM 1	1	1	2	0.15	240
2-327	HAND EXAM 8	1	1	1	0.15	240
2-332	ORTHO. MD WORK 3	1	1	2	0.15	240
2-338	ORTHO. EXAM 12	1	1	1	0.15	240
2-337	ORTHO. EXAM 13	1	1	1	0.15	240
2-331	ORTHO. SURG. SCH. WORK	1	1	2	0.15	240
2-326	HAND EXAM 7	1	1	1	0.15	240
2-319	HAND EXAM 2	1	1	1	0.15	240
2-316, 2-	HAND THERAPY	3	3	13	0.15	720
2-248	UROL. MED. TREATMT 3	2	2	2	0.15	480
2-320	WHIRLPOOL	1	1	1	0.15	240
2-250	UROL. MED TREATMT.	2	2	2	0.15	480
2-249	UROL. LG. TREATMT. 1	2	2	2	0.15	480
2-240	UROL. MED. TREATMENT 2	2	2	2	0.15	480

2-242	HC PAT TLT.	1	1		0.15	240
2-243	HC PAT TLT.	2	2		0.15	480
2-245	HC PAT TLT.	2	2		0.15	480
2-246	HC PAT TLT.	1	1		0.15	240
2-241	UROL. LG. TREATMT 2	1	1	2	0.15	240
2-239	HC PAT TLT.	2	2		0.15	480
2-244	UROL. LG. TREATMT 3	1	1	2	0.15	240
2-253	UROL. EXAM 14	1	1	2	0.15	240
2-252	UROL. EXAM 13	1	1	1	0.15	240
2-238	UROL. EXAM 12	1	1	2	0.15	240
2-237	UROL. SOIL. HOLD.	1	1	0	0.15	240
2-236	UROL. CL. SUPPL.	1	1	0	0.15	240
2-228	UROL. EXAM 11	1	1	2	0.15	240
2-225	UROL. EXAM 10	1	1	1	0.15	240
2-224	UROL. EXAM 9	1	1	2	0.15	240
2-209	UROL. EXAM 8	1	1	1	0.15	240
2-208	UROL. EXAM 7	1	1	2	0.15	240
2-229	UROL RN WORK	2	2	1	0.15	480
2-227	HC PAT TLT.	1	1		0.15	240
2-223	HC PAT TLT.	1	1		0.15	240
2-221	PAT. TLT.	2	2		0.15	480
2-222	TRNB PROC. 1	2	2	2	0.15	480
2-219	HC PAT TLT.	2	2		0.15	480
2-218	PAT TLT.	2	2		0.15	480
2-220	CYSTO PROC. 1	3	3	2	0.15	720
2-230	UROL. MD. WORK/PACS	3	3	4	0.15	720
2-217	TRNB PROC. 2	3	3	2	0.15	720
2-216	HC PAT TLT.	2	2		0.15	480
2-215	PAT TLT.	2	2		0.15	480
2-213	PAT TLT.	2	2		0.15	480
2-212	HC PAT TLT.	2	2		0.15	480
2-214	CYSTO. PROC. 2	3	3	2	0.15	720
2-206	UROL. EXAM 6	1	1	2	0.15	240
2-205	UROL. EXAM 5	1	1	1	0.15	240
2-204	UROL. EXAM 4	1	1	2	0.15	240
2-203	UROL EXAM 3	1	1	1	0.15	240
2-202	UROL EXAM 2	1	1	2	0.15	240
2-201	UROL. EXAM 1	1	1	1	0.15	240
2-308	HAND CAST ROOM	1	1	3	0.15	240
2-307	HAND EXAM 4	1	1	2	0.15	240
2-112	SCHEDULING REGISTRATION	2	2	9	0.15	480
2-311	HAND EXAM 5	1	1	2	0.15	240
2-314	ORTHO. MD WORK 2	1	1	2	0.15	240
2-323	HC PAT TLT.	1	1		0.15	240
2-328	ORTHO. EXAM 11	1	1	2	0.15	240
2-325	HAND EXAM 6	1	1	1	0.15	240
2-330	ORTHO. EXAM 9	1	1	2	0.15	240

2-336	ORTHO. MD WORK 4	1	1	1	0.15	240
2-324	SOIL HOLD	1	1	0	0.15	240
2-329	ORTHO. EXAM 10	1	1	1	0.15	240
2-335	ORTHO. EXAM 14	1	1	2	0.15	240
2-334	ORTHO. EXAM 15	1	1	1	0.15	240
NUM	STAIRWAY#1	1	1		0.2	220
NUM	HORIZONTAL EXIT DOORS	3	3		0.15	720
WEST OF HORIZONTAL EXIT						
2-377	FAX/COPY	1	1	1	0.15	240
2-366	BREAK/VEND	1	1	16	0.15	240
2-365	ORTHO. MD. 12	1	1	1	0.15	240
2-364	ORTHO. PA SUPV.	1	1	1	0.15	240
2-363	STAFF F. TLT	1	1		0.15	240
2-362	STAFF M. TLT.	1	1		0.15	240
2-361	CAST EQ. STG.	1	1	1	0.15	240
2-256	HC STAFF TLT.	1	1		0.15	240
2-254A	ELEC.	1	1	0	0.15	240
2-317	ORTHO. MD WORK 1	1	1	2	0.15	240
2-315	HAND EXAM 3	1	1	1	0.15	240
NUM	ELEC.	1	1	0	0.15	240
2-231	UROL. SOIL EQ	1	1	0	0.15	240
2-343	ORTHO. EXAM 20	1	1	2	0.15	240
2-342	ORTHO. MD WORK 5	1	1	2	0.15	240
2-341	ORTHO. CL. SUPLY.	1	1	1	0.15	240
2-340	ORTHO. EXAM 19	1	1	2	0.15	240
2-339	ORTHO. EXAM 18	1	1	1	0.15	240
2-347	ORTHO. EXAM 21	1	1	2	0.15	240
2-346	ORTHO. EXAM 22	1	1	1	0.15	240
2-345	ORTHO. EXAM 23	1	1	2	0.15	240
2-349	ORTHO. EXAM 25	1	1	1	0.15	240
2-348	ORTHO. EXAM 24	1	1	2	0.15	240
2-350	JAN.	1	1	1	0.15	240
2-354	ORTHO. MD WORK 7	1	1	3	0.15	240
2-353	ORTHO. EXAM 26	1	1	2	0.15	240
2-352	ORTHO. EXAM 27	1	1	1	0.15	240
2-355	ORTHO. EXAM 28	1	1	2	0.15	240
2-360	CAST ROOM	2	2	10	0.15	480
2-359	ORTHO. MD WORK 8	1	1	1	0.15	240
2-358	PAT TLT.	1	1		0.15	240
2-434	ULTRA SOUND	1	1	2	0.15	240
2-433	ULTRA SOUND	1	1	2	0.15	240
2-431A	ULTRA TECH	1	1	1	0.15	240
2-430, 2-	M. DRESS.	1	1	4	0.15	240
2-432	HC ULTRA TLT.	1	1		0.15	240
2-431B	ELEC.	1	1	0	0.15	240
2-421	RAD 1	1	1	4	0.15	240
2-420	RAD 2	1	1	4	0.15	240

2-418	RAD MD	1	1	1	0.15	240
2-417	RAD READ	1	1	4	0.15	240
2-416	TECH WORK	2	2	6	0.15	480
2-415	CHEST 1	1	1	3	0.15	240
2-414	RAD 3	1	1	3	0.15	240
2-406	F. DRESS.	1	1	8	0.15	240
2-412	HC PAT TLT.	1	1		0.15	240
2-103	F. TLT.	1	1		0.15	240
2-102	M. TLT.	1	1		0.15	240
2-306	JAN.	1	1	0	0.15	240
2-304	ORTHO. EXAM 17	1	1	1	0.15	240
2-302	ORTHO. EXAM 16	1	1	2	0.15	240
2-301	ORTHO. MD WORK 6	1	1	1	0.15	240
2-110	REGISTRATION	2	2	4	0.15	480
2-106	LOBBY AND WAITING AREAS	3	4	234	0.15	960
2-107	WHLCHR STG.	1	1	0	0.15	240
NUM	STAIRWAY#2	1	1		0.2	220
NUM	HORIZONTAL EXIT DOORS	3	3		0.15	720
NUM	WEST HORIZONTAL EXIT	1	1		0.15	240
EXITS FOR ENTIRE FLOOR						
NUM	STAIRWAY#1	1	1		0.2	220
NUM	STAIRWAY#2	1	1		0.2	220
NUM	WEST HORIZONTAL EXIT	1	1		0.15	240

TOTAL OCC. LOAD EAST OF HORIZ. EXIT	**170**
TOTAL EXIT CAP. EAST OF HORIZ. EXT	**940**
EAST - 50% REQ'D CAP.	**85**
EAST - 1 EXIT COMPROMISED CAP.	**720**
TOTAL OCC. LOAD WEST OF HORIZ. EXIT	**343**
TOTAL EXIT CAP. WEST OF HORIZ. EXIT	**1180**
WEST - 50% REQ'D CAP.	**172**
WEST - 1 EXIT COMPROMISED CAP.	**940**
TOTAL OCC. LOAD	**513**
TOTAL FLOOR EXIT CAPACITY	**680**
FLOOR - 50% REQ'D CAP.	**257**
FLOOR - 1 EXIT COMPROMISED CAP.	**440**

THIRD FLOOR						
RM#	NAME	#EXITS	#DOORS	OCC. LOAD	EXIT CAP. FACTOR	EXIT CAP.
EAST OF HORIZONTAL EXIT						
3-223	GYN MD	1	1	1	0.15	240
3-224	GYN MD 2	1	1	1	0.15	240
3-225	GYN MD 3	1	1	1	0.15	240
3-226	GYN MD 4	1	1	1	0.15	240
3-227	GYN MD 5	1	1	1	0.15	240
3-228	GYN MD 6	1	1	1	0.15	240
3-306	PLAS MD 1	1	1	1	0.15	240
3-307	PLAS MD 2	1	1	1	0.15	240
3-308	PLAS MD 3	1	1	1	0.15	240
3-309	PLAS MD 4	1	1	1	0.15	240
3-502	GEN SURG MD 1	1	1	1	0.15	240
3-503	GEN SURG MD 2	1	1	1	0.15	240
3-504	GEN SURG MD 3	1	1	1	0.15	240
NUM	IDF TERM	1	1	1	0.15	240
3-505	GEN SURG MD 4	1	1	1	0.15	240
3-506	GEN SURG MD 5	1	1	1	0.15	240
3-221	HC STAFF TLT	1	1		0.15	240
3-222	FAX/COPY	2	2	1	0.15	480
3-230	GYNECOLOGY OPEN OFFICE	1	1	2	0.15	240
3-305	PLASTICS OPEN OFFICE	1	1	2	0.15	240
3-326	PLAS/PA AESTH WORK	1	1	2	0.15	240
3-408	PRAC ADMIN 1	1	1	1	0.15	240
3-407	PRAC ADMIN 3	1	1	1	0.15	240
3-219	GYN EXAM 10	1	1	2	0.15	240
3-218	GYN EXAM 9	1	1	1	0.15	240
3-217	GYN EXAM 8	1	1	2	0.15	240
3-216	GYN MD WORK	1	1	1	0.15	240
3-215	GYN EXAM 7	1	1	2	0.15	240
3-214	GYN EXAM 6	1	1	1	0.15	240
3-213	GYN EXAM 5	1	1	2	0.15	240
3-212	GYN EXAM 4	1	1	1	0.15	240
3-211	GYN RN WORK	1	1	2	0.15	240
3-210	GYN MD WORK	1	1	1	0.15	240
3-209	GYN EXAM 3	1	1	2	0.15	240
3-208	GYN EXAM 2	1	1	1	0.15	240
3-207	GYN EXAM 1	1	1	2	0.15	240
3-231	GYN EXAM 11	1	1	2	0.15	240
3-246	GYN S. HOLD	1	1	0	0.15	240
3-232	HC PAT TLT.	1	1		0.15	240
3-245	GYN FELLOWS WORK	1	1	2	0.15	240
3-233	GYN EXAM 12	1	1	1	0.15	240
3-243	HC PAT TLT.	1	1		0.15	240
3-244	STG.	1	1	0	0.15	240
3-234	GYN EXAM 13	1	1	2	0.15	240

3-205B	ELEC.	1	1	0	0.15	240
3-205A	SCOPE NICHE	1	1	0	0.15	240
3-310	PLAS PHOTO	1	1	2	0.15	240
3-247	HC STAFF TLT	1	1		0.15	240
3-248	HC STAFF TLT	1	1		0.15	240
3-311	SUBWAIT	1	1	1	0.15	240
3-249	SHARED CONF	1	1	17	0.15	240
3-312	PLAS EXAM 1	1	1	2	0.15	240
3-250	GYN CL SUP	1	1	0	0.15	240
3-251	CLEAN SUPP	1	1	0	0.15	240
3-313	PLAS EXAM 2	1	1	1	0.15	240
3-409	PRAC ADMIN 2	1	1	1	0.15	240
3-325	PLAS/GEN SURG EXAM 1	1	1	2	0.15	240
3-410	FAX/COPY	1	1	1	0.15	240
3-324	PLAS EXAM 7	1	1	1	0.15	240
3-411	ADMIN OPEN OFFICE	1	1	3	0.15	240
3-323	PLAS MD/FELLOWS WK	1	1	2	0.15	240
3-406	PRAC ADMIN 4	1	1	1	0.15	240
3-405	PRAC INTER OFFICE	1	1	1	0.15	240
3-405A	PRAC INTER OFFICE	1	1	1	0.15	240
3-403	JAN.	1	1	0	0.15	240
3-237	HC PAT TLT.	1	1		0.15	240
3-236	HC PAT TLT.	1	1		0.15	240
3-240	HC PAT TLT.	1	1		0.15	240
3-235	GYN EXAM 14	1	1	2	0.15	240
3-241	GYN EXAM 17	1	1	1	0.15	240
3-238	GYN EXAM 15	1	1	2	0.15	240
3-239	GYN EXAM 16	1	1	1	0.15	240
3-252	SCOPE NICHE	1	1	1	0.15	240
3-253	GYN NURSE MGR	1	1	1	0.15	240
3-314	PLAS CL SUPP	1	1	0	0.15	240
3-315	PLAS S. HOLD	1	1	0	0.15	240
3-254	GYN EXAM 18	1	1	1	0.15	240
3-316	PLAS EXAM 3	1	1	2	0.15	240
3-255	GYN STG.	1	1	0	0.15	240
3-317	PLAS EXAM 4	1	1	2	0.15	240
3-322	PLAS INTERV.	1	1	1	0.15	240
3-321	PLAS STOR	1	1	0	0.15	240
3-319	PLAS EXAM 6	1	1	2	0.15	240
3-318	PLAS EXAM 5	1	1	1	0.15	240
3-320	SHARED CONF	1	1	14	0.15	240
NUM	STAIRWAY#1	1	1		0.2	220
NUM	HORIZONTAL EXIT DOORS	5	5		0.15	1200
WEST OF HORIZONTAL EXIT						
3-229	GYN MD 7	1	1	1	0.15	240
3-507	GEN SURG MD 6	1	1	1	0.15	240
3-508	GEN SURG MD 7	1	1	1	0.15	240

3-509	GEN SURG MD 8	1	1	1	0.15	240
3-510	GEN SURG MD 9	1	1	1	0.15	240
3-511	GEN SURG MD 10	1	1	1	0.15	240
3-512	GEN SURG MD 11	1	1	1	0.15	240
3-513	GEN SURG MD 12	1	1	1	0.15	240
3-558	JAN.	1	1	0	0.15	240
3-571	STAFF M TLT.	1	1		0.15	240
3-570	STAFF F. TLT	1	1		0.15	240
3-562	HC PAT TLT.	1	1		0.15	240
3-564	HC PAT TLT.	1	1		0.15	240
3-559	SOIL HOLD	1	1	0	0.15	240
3-566	INANIMATE LAB	1	1	8	0.15	240
3-613	POME EXAM 6	1	1	2	0.15	240
3-614	POME EXAM 7	1	1	1	0.15	240
3-615	POME EXAM 8	1	1	2	0.15	240
3-616	POME EXAM 9	1	1	1	0.15	240
3-618	POME MD/PA WORK	1	1	2	0.15	240
3-551	GEN SURG OSTOMY EXAM 14	1	1	1	0.15	240
3-548	GEN SURG STOMY EXAM 13	1	1	2	0.15	240
3-612	POME EXAM 5	1	1	1	0.15	240
3-611	POME EXAM 4	1	1	2	0.15	240
3-610	POME EXAM 3	1	1	1	0.15	240
3-609	POME EXAM 2	1	1	2	0.15	240
3-547	GEN SURG EXAM 12	1	1	1	0.15	240
3-550	HC PAT TLT.	1	1		0.15	240
3-602	SCHED	1	1	2	0.15	240
3-619	POME INTER 1	1	1	1	0.15	240
3-620	POME INTER 2	1	1	2	0.15	240
3-621	POME COORD	1	1	1	0.15	240
3-622	POME MD 1	1	1	2	0.15	240
3-623	POME MD 2	1	1	1	0.15	240
3-608	POME EXAM 1	1	1	2	0.15	240
3-607	STG.	1	1	0	0.15	240
3-606	HC PAT TLT	1	1		0.15	240
3-603	POME OPEN OFFICE	2	2	3	0.15	480
3-546	GEN SURG EXAM 11	1	1	2	0.15	240
3-543	HC PAT TLT.	1	1		0.15	240
3-544	GEN SURG EXAM 6	1	1	2	0.15	240
3-535	GEN SURG MA WORK/SCHED	1	1	1	0.15	240
3-557	CLEAN SUPP	1	1	0	0.15	240
3-536	GEN SURG CLN SUPP	1	1	0	0.15	240
3-555	GEN SURG S. HOLD	1	1	0	0.15	240
3-539	GEN SURG/MD WORK	2	2	3	0.15	480
3-537	GEN SURG EXAM 5	1	1	2	0.15	240
3-554	GEN SURG EXAM 9	1	1	1	0.15	240
3-538	GEN SURG EXAM 7	1	1	2	0.15	240
3-553	GEN SURG EXAM 10	1	1	1	0.15	240

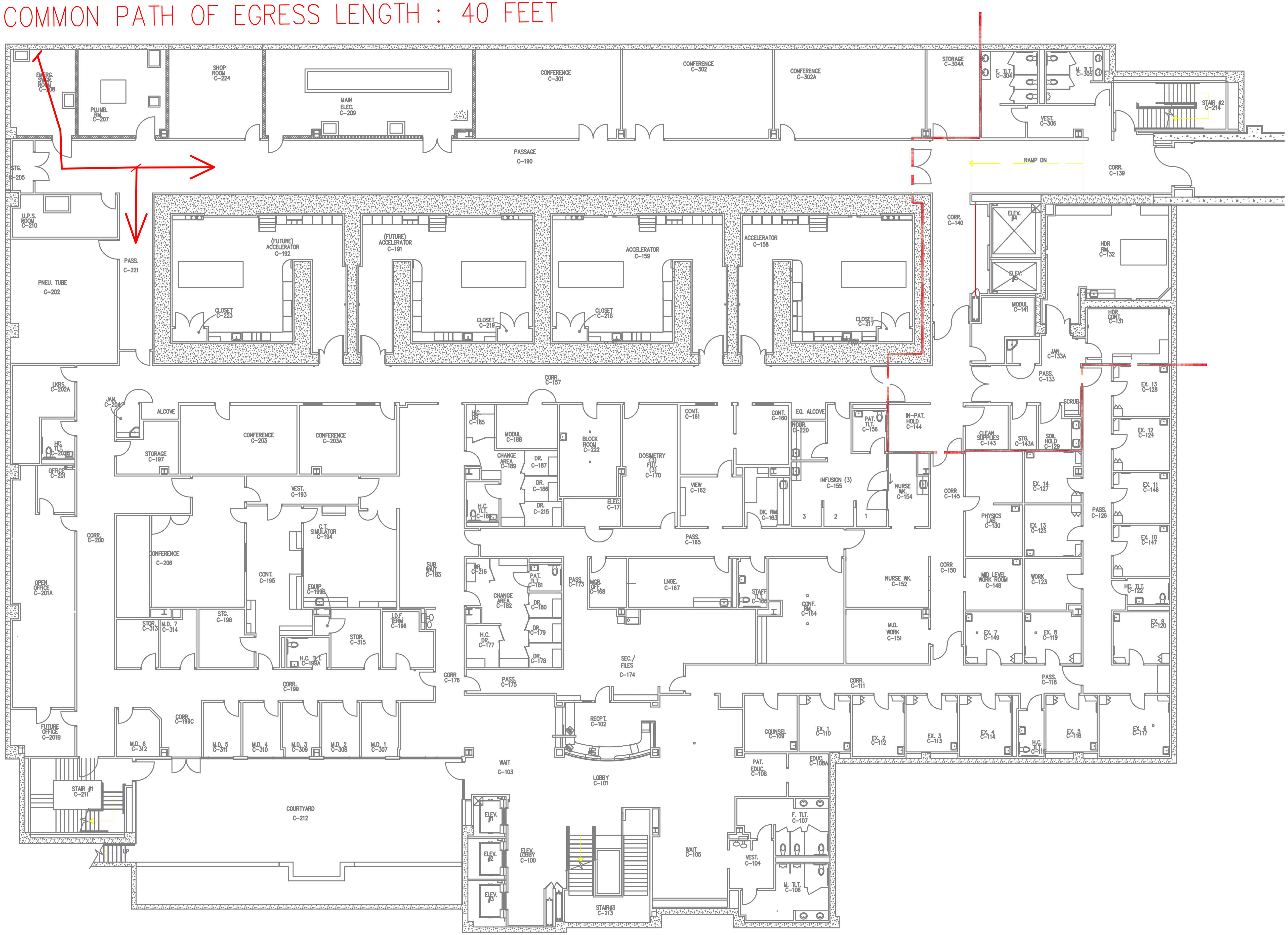
3-533	GEN SURG MD WORK	1	1	2	0.15	240
3-532	GEN SURG EXAM 1	1	1	1	0.15	240
3-531	GEN SURG STG	1	1	1	0.15	240
3-530	GEN SURG EXAM 2	1	1	2	0.15	240
3-529	GEN SURG EXAM 3	1	1	1	0.15	240
3-516	GEN SURG SECY	2	2	4	0.15	480
3-522	GEN SURG EDUC COORD	1	1	2	0.15	240
3-523	GEN SURG PA WORK	1	1	1	0.15	240
3-524	GEN SURG RN WORK	1	1	2	0.15	240
3-516	VIP EDI	1	1	1	0.15	240
3-517	GEN SURG SEC	1	1	1	0.15	240
3-518	ALCOVE	1	1	1	0.15	240
3-520	GEN SURG RESIDENT/FELLOWS W	1	1	3	0.15	240
3-519	GEN SURG FILE STG	1	1	0	0.15	240
NUM	ELEC.	1	1	1	0.15	240
3-528	GEN SURG EXAM 4	1	1	2	0.15	240
3-527	GEN SURG EXAM 5	1	1	2	0.15	240
3-110	BACK SCHEDULING AND REGISTR/	4	4	9	0.15	960
3-108	REGISTRATION	4	4	5	0.15	960
3-106	F. TLT.	1	1		0.15	240
3-107	M. TLT	1	1		0.15	240
3-101A	WHLCHR STG	1	1	0	0.15	240
3-101	LOBBY AND WAITING AREAS	6	9	306	0.15	2160
NUM	STAIRWAY#2	1	1		0.2	220
NUM	HORIZONTAL EXIT DOORS	5	5		0.15	1200
NUM	WEST HORIZONTAL EXIT	1	1		0.15	240
EXITS FOR ENTIRE FLOOR						
NUM	STAIRWAY#1	1	1		0.2	220
NUM	STAIRWAY#2	1	1		0.2	220
NUM	WEST HORIZONTAL EXIT	1	1		0.15	240

TOTAL OCC. LOAD EAST OF HORIZ. EXIT	**119**
TOTAL EXIT CAP. EAST OF HORIZ. EXIT	**1420**
EAST - 50% REQ'D CAP.	**60**
EAST - 1 EXIT COMPROMISED CAP.	**1200**
TOTAL OCC. LOAD WEST OF HORIZ. EXIT	**409**
TOTAL EXIT CAP. WEST OF HORIZ. EXIT	**1660**
WEST - 50% REQ'D CAP.	**205**
WEST - 1 EXIT COMPROMISED CAP.	**1420**
TOTAL OCC. LOAD	**528**
TOTAL FLOOR EXIT CAPACITY	**680**
FLOOR - 50% REQ'D CAP.	**264**
FLOOR - 1 EXIT COMPROMISED CAP.	**440**

Appendix L

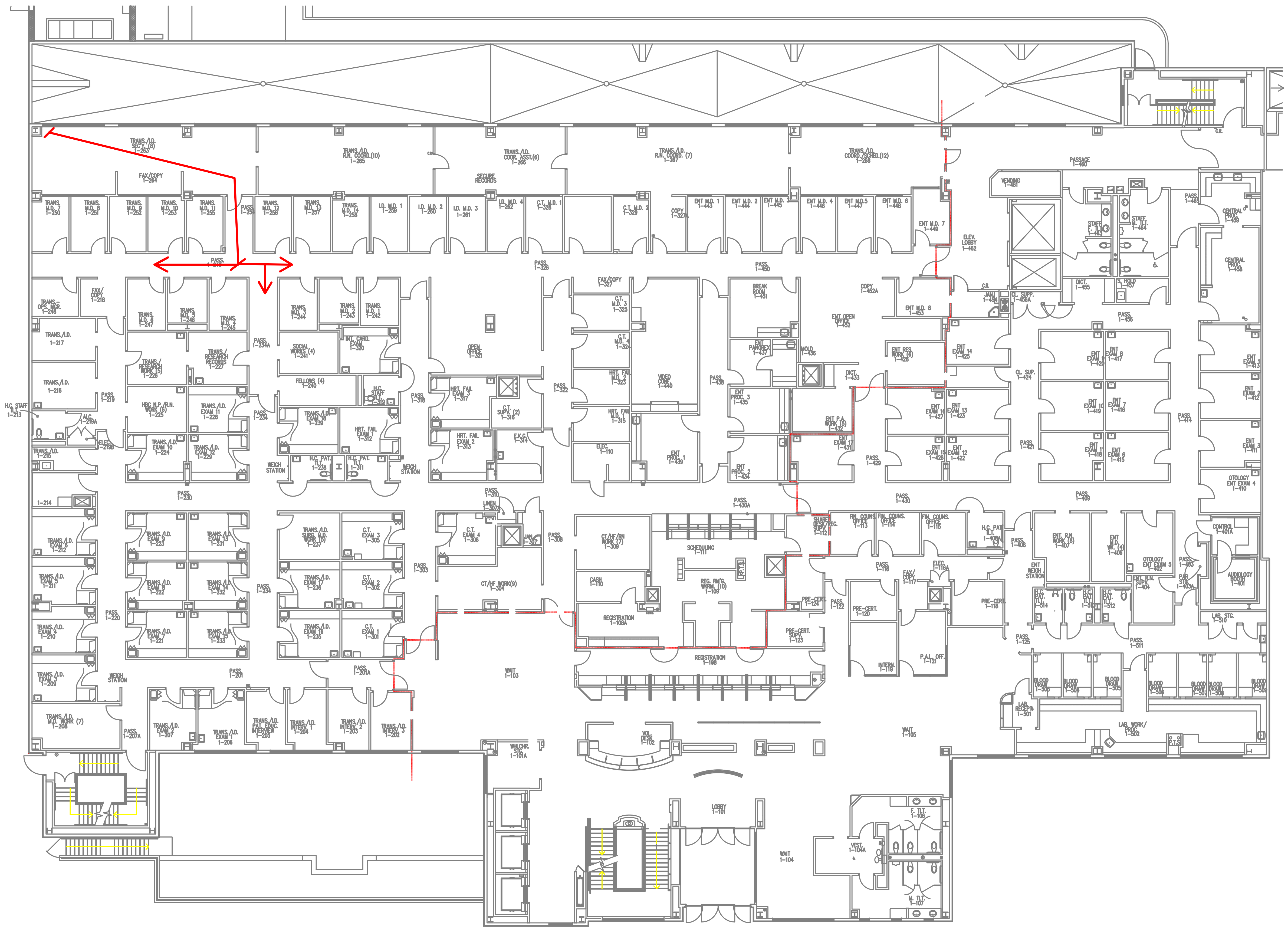
CONCOURSE FLOOR

COMMON PATH OF EGRESS LENGTH : 40 FEET



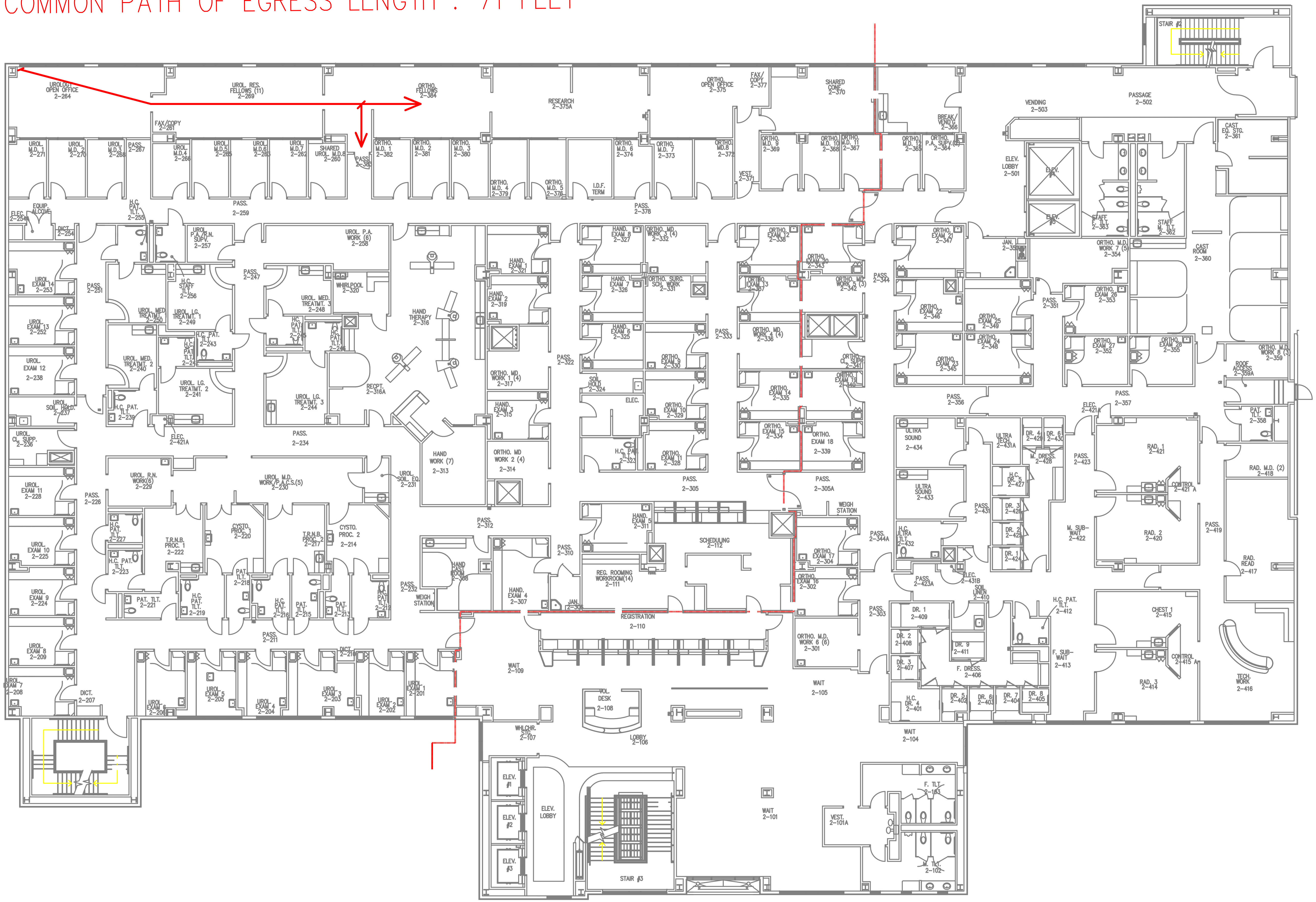
FIRST FLOOR

COMMON PATH OF EGRESS LENGTH : 60 FEET



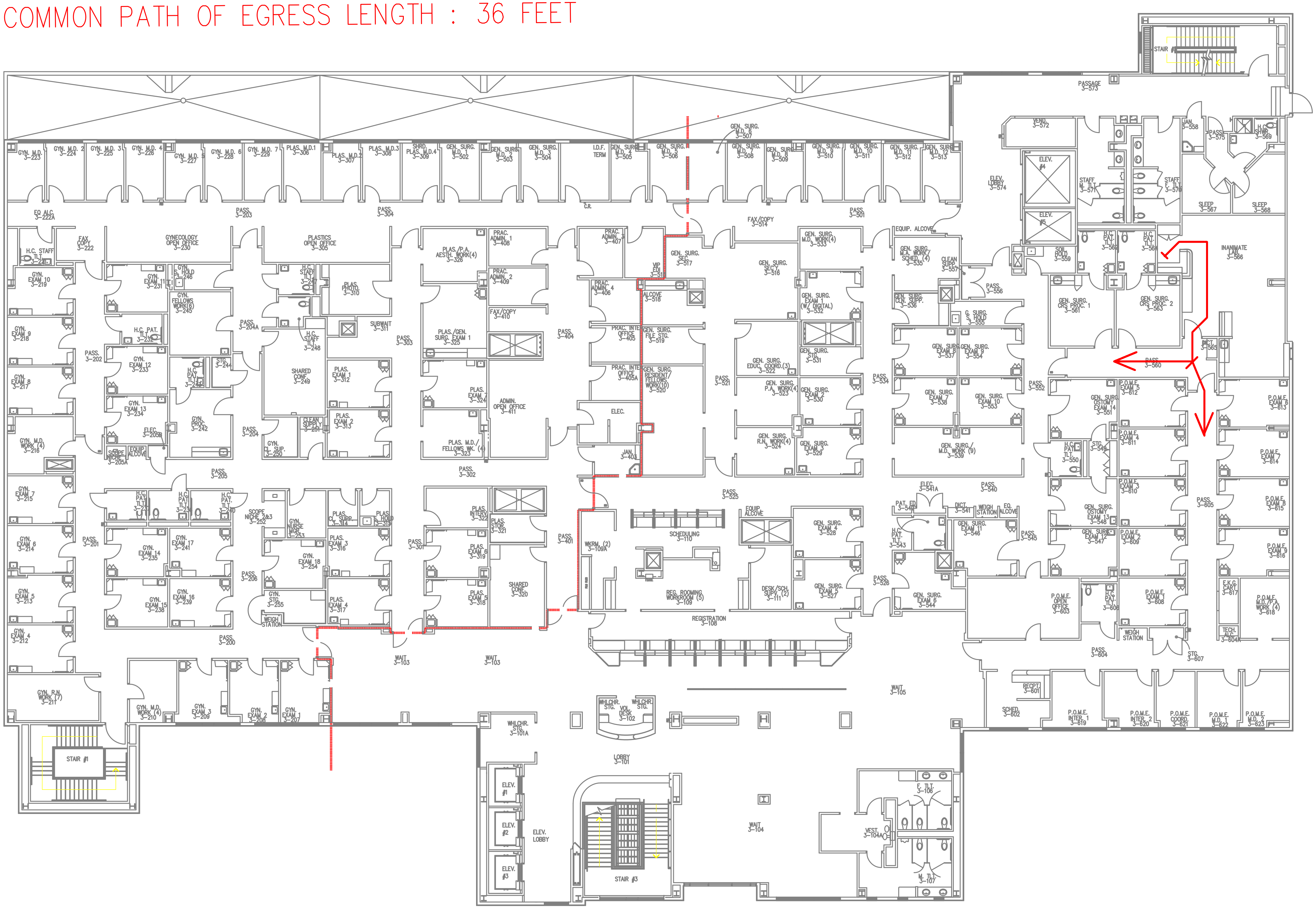
SECOND FLOOR

COMMON PATH OF EGRESS LENGTH : 71 FEET



THIRD FLOOR

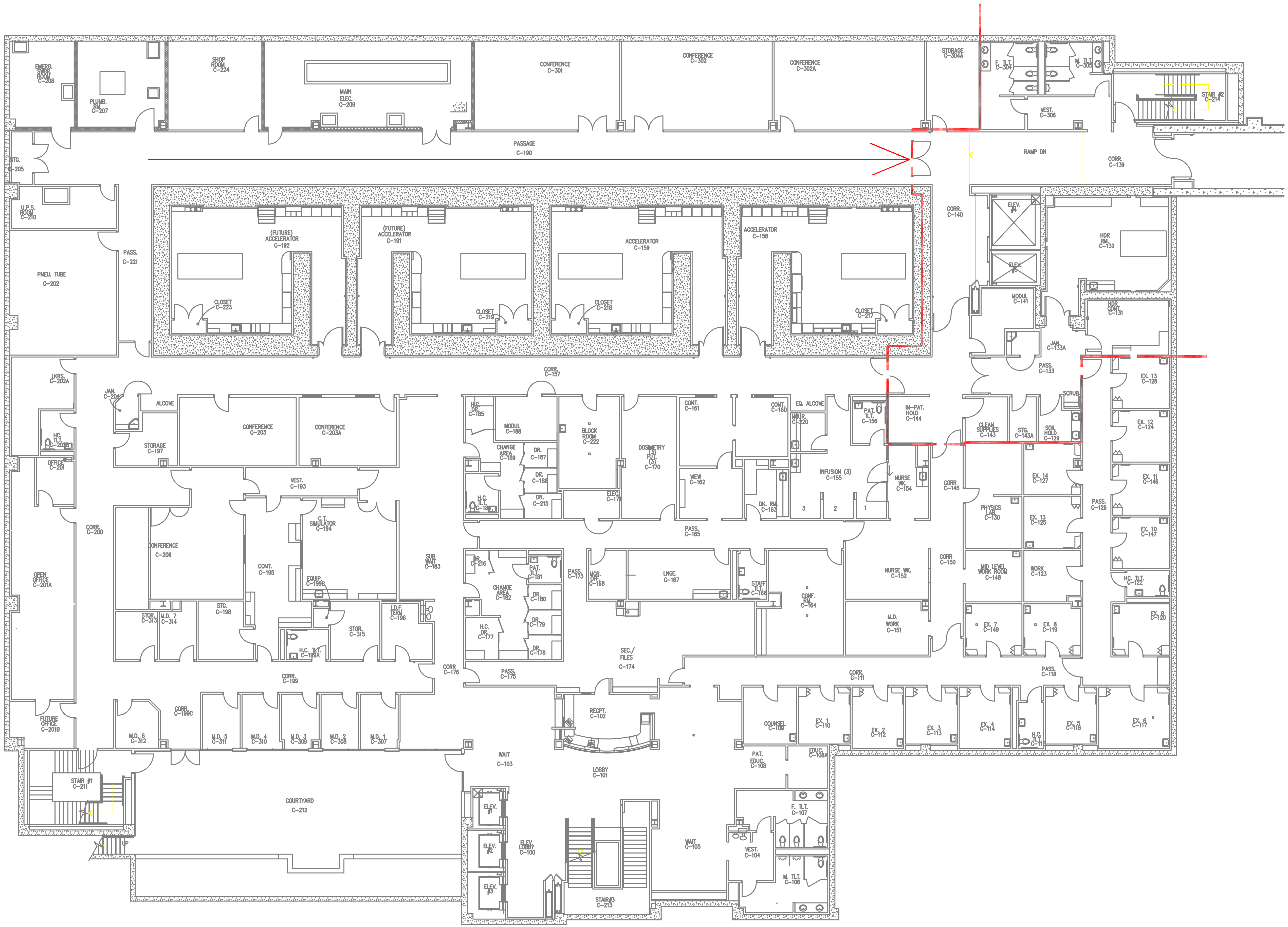
COMMON PATH OF EGRESS LENGTH : 36 FEET



Appendix M

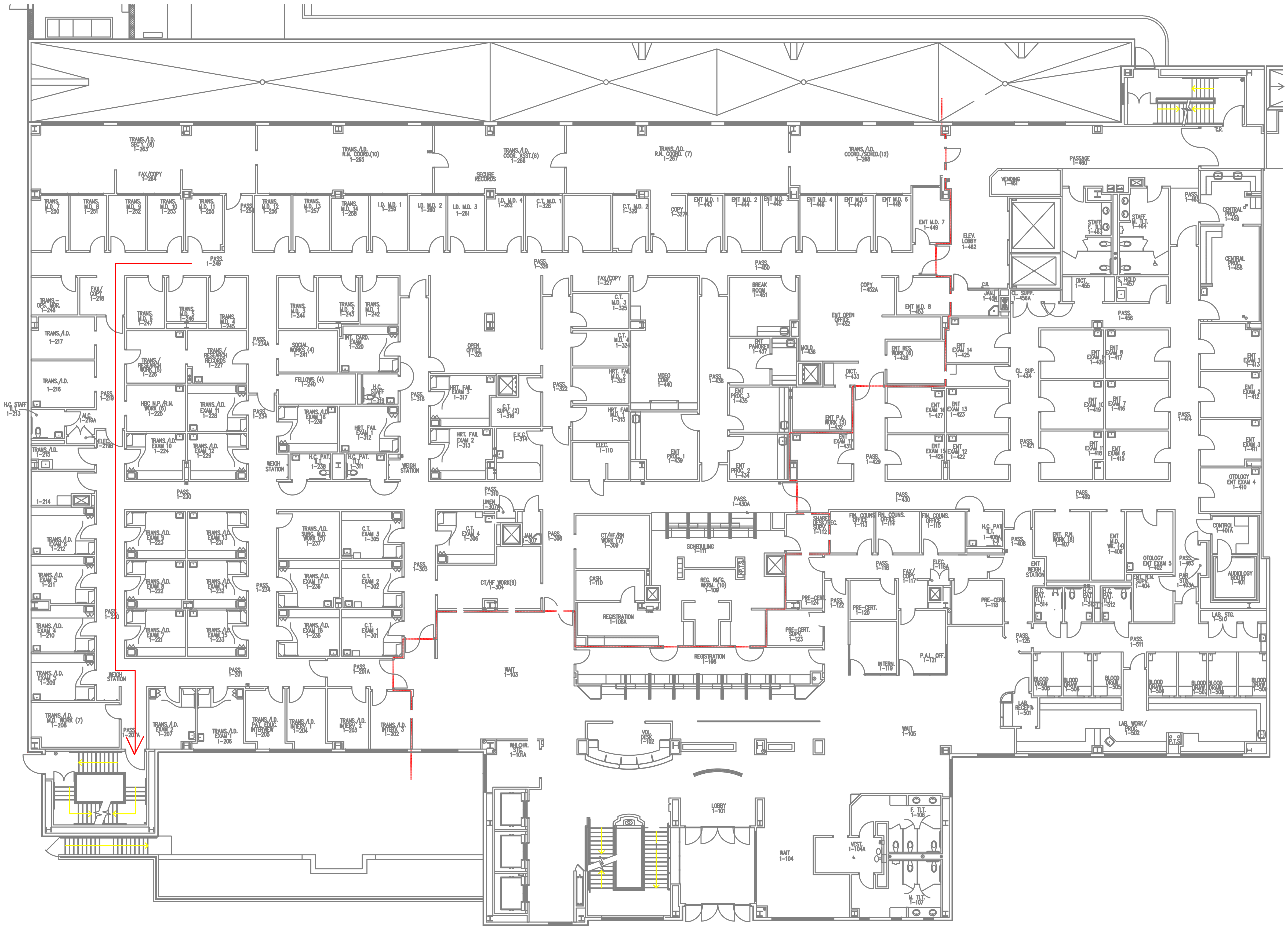
CONCOURSE FLOOR

EXIT ACCESS LONGEST TRAVEL DISTANCE : 148 FEET



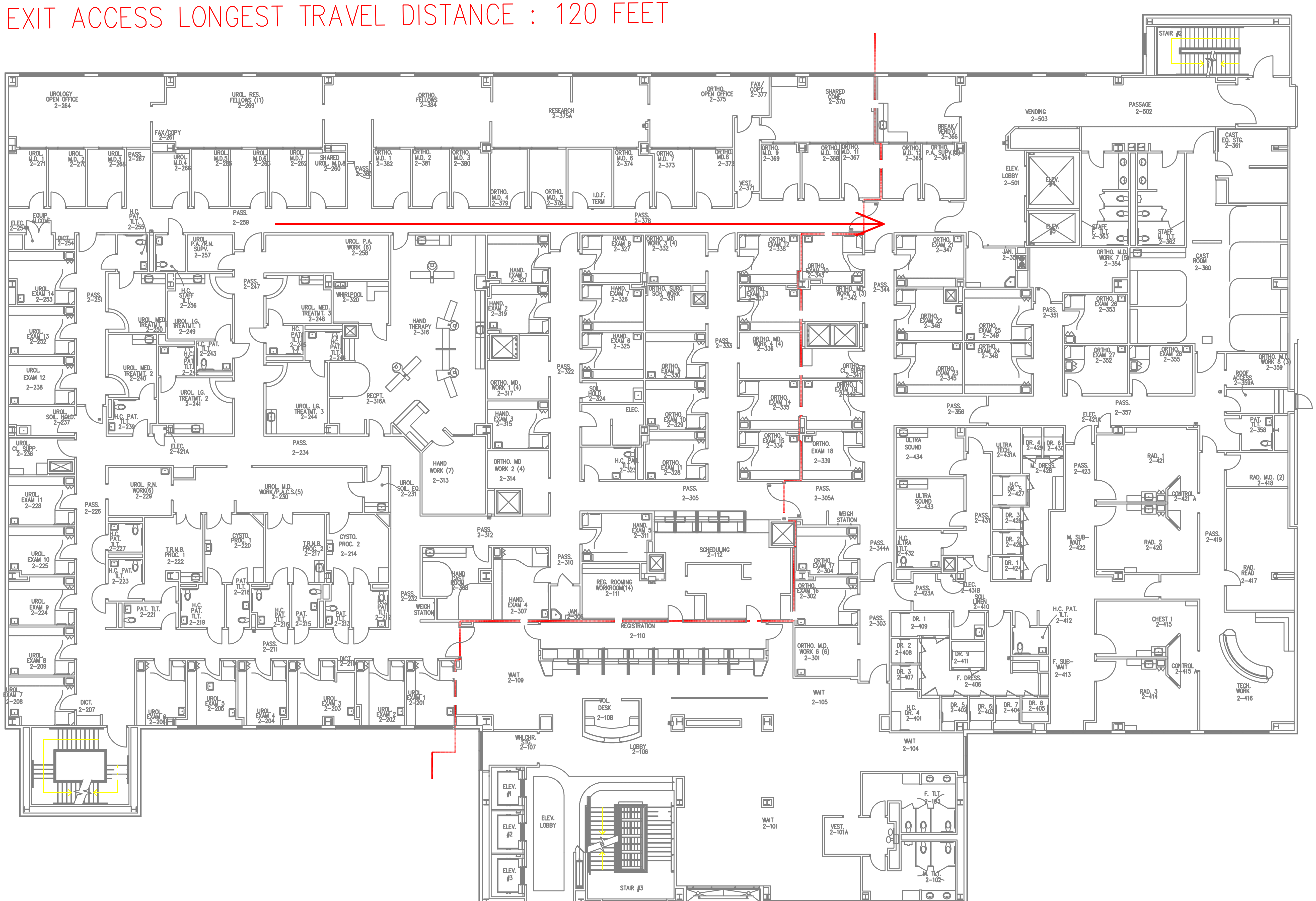
FIRST FLOOR

EXIT ACCESS LONGEST TRAVEL DISTANCE : 130 FEET



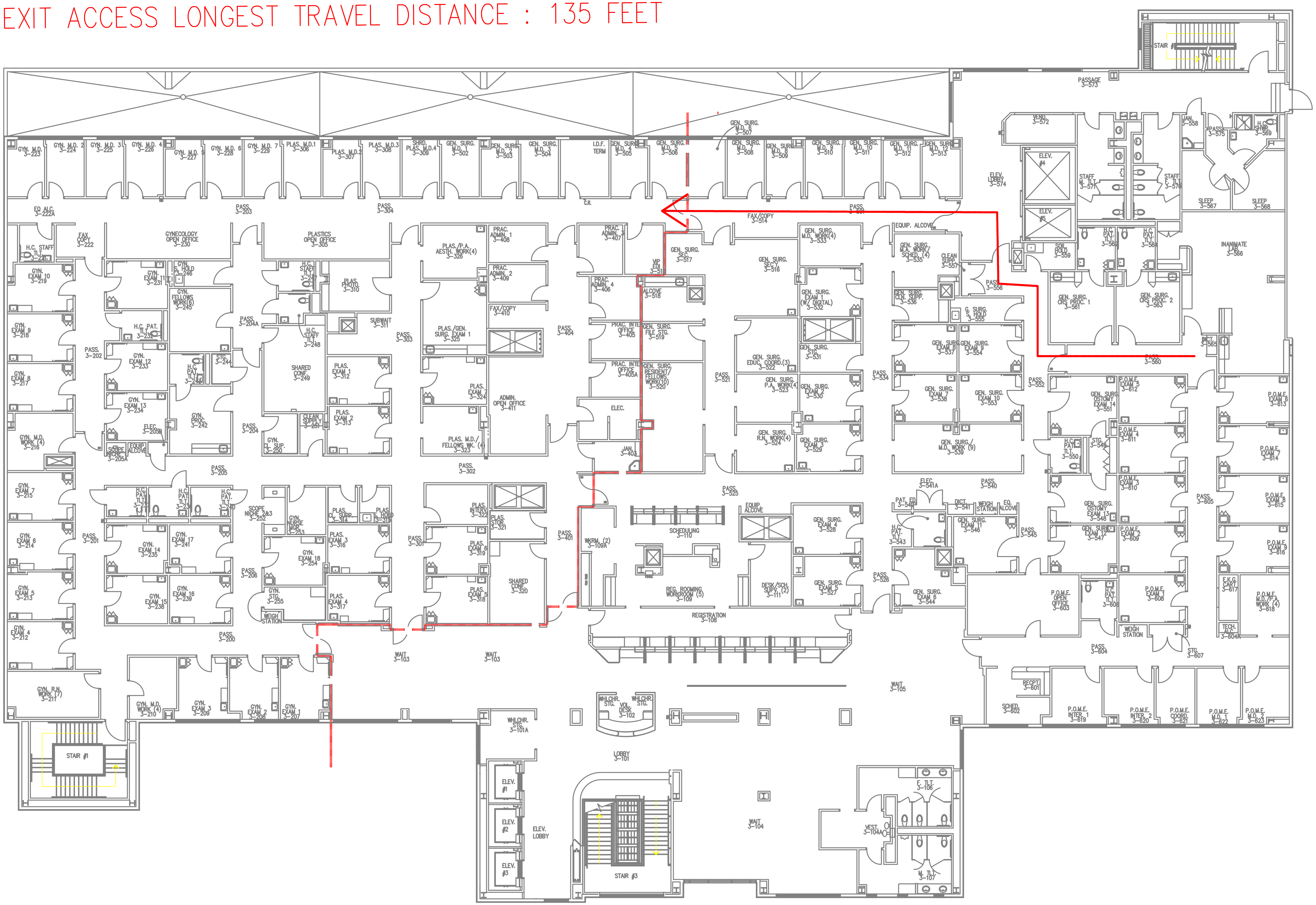
SECOND FLOOR

EXIT ACCESS LONGEST TRAVEL DISTANCE : 120 FEET



THIRD FLOOR

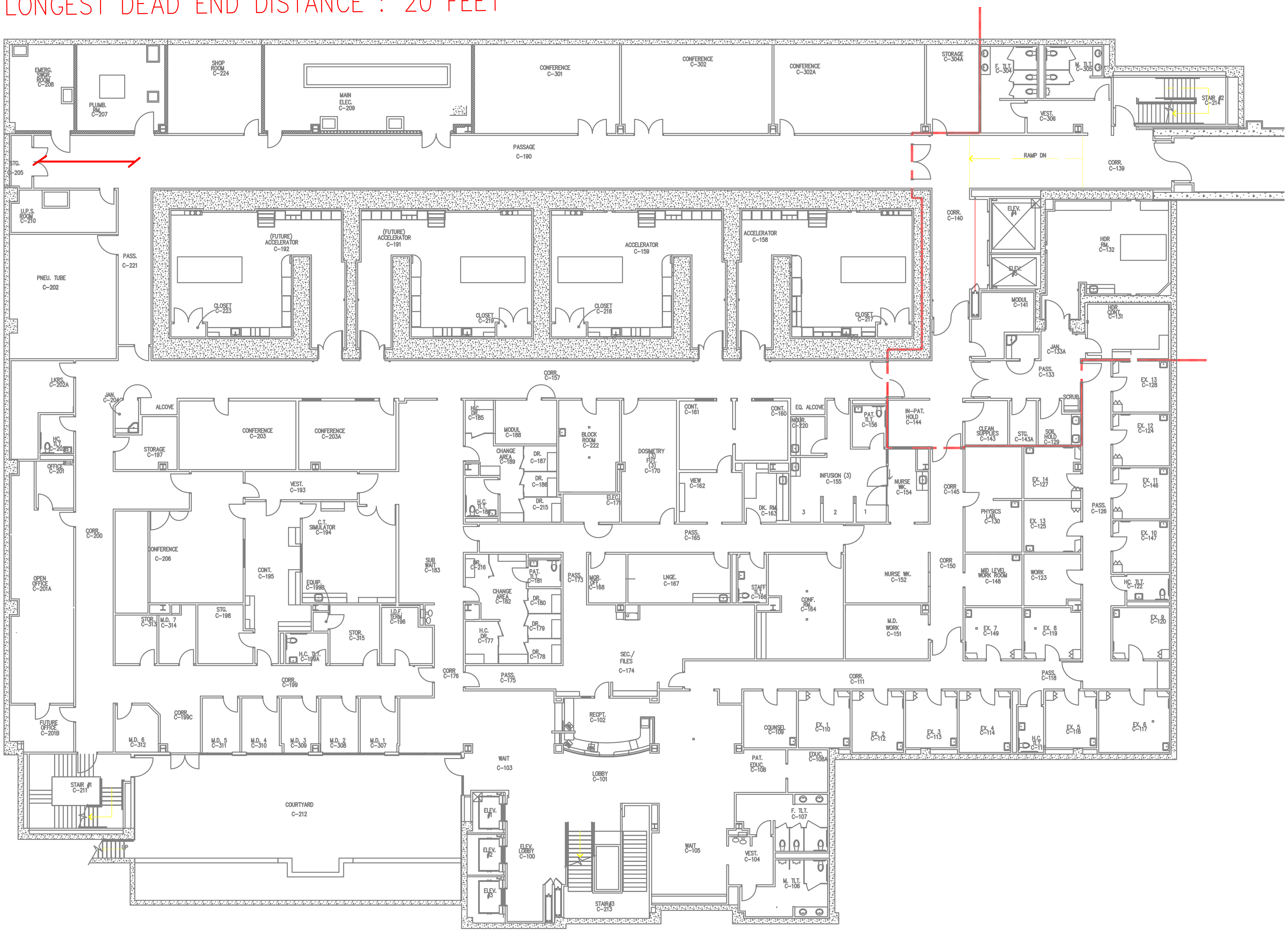
EXIT ACCESS LONGEST TRAVEL DISTANCE : 135 FEET



Appendix N

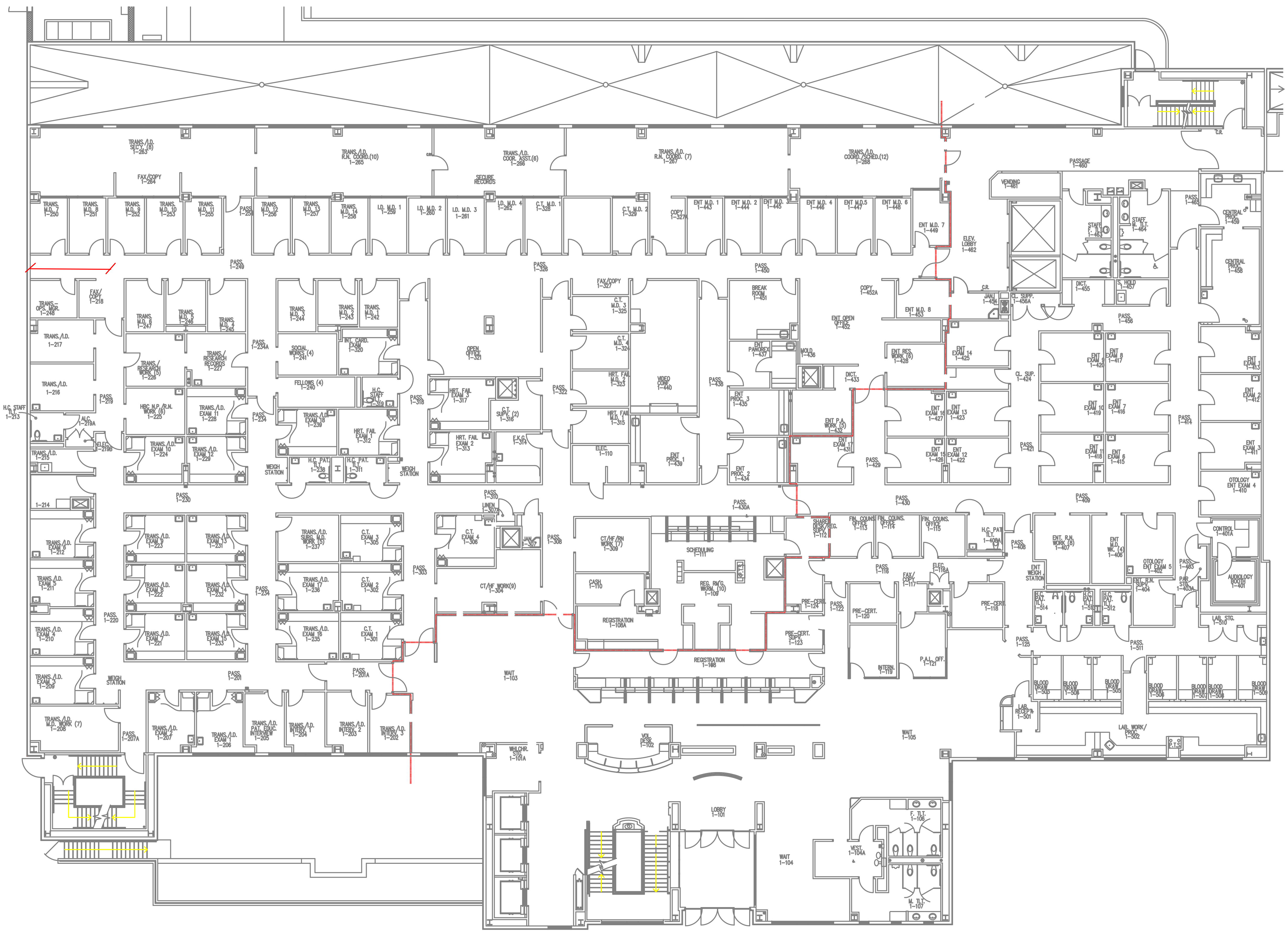
CONCOURSE FLOOR

LONGEST DEAD END DISTANCE : 20 FEET



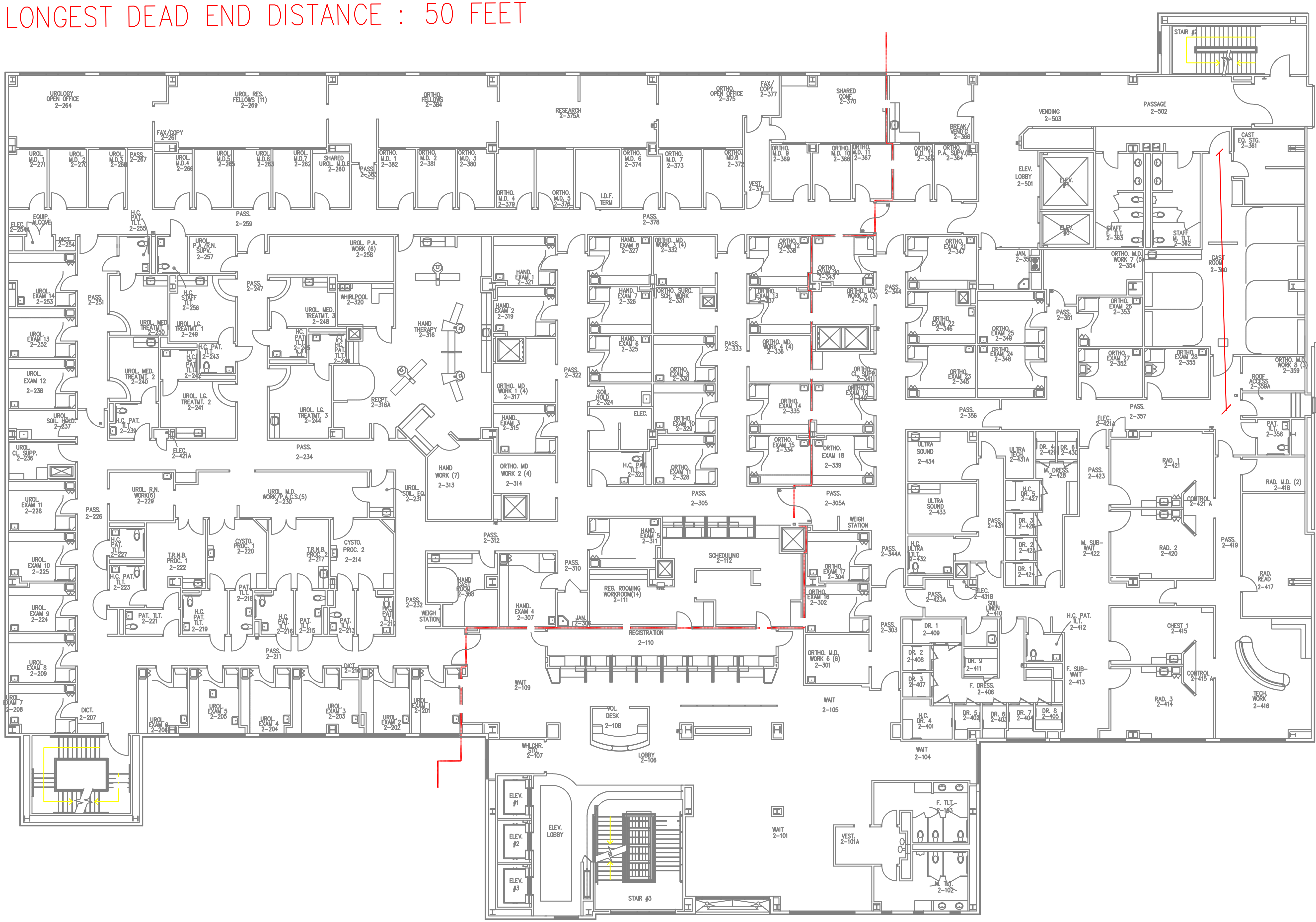
FIRST FLOOR

LONGEST DEAD END DISTANCE : 17 FEET



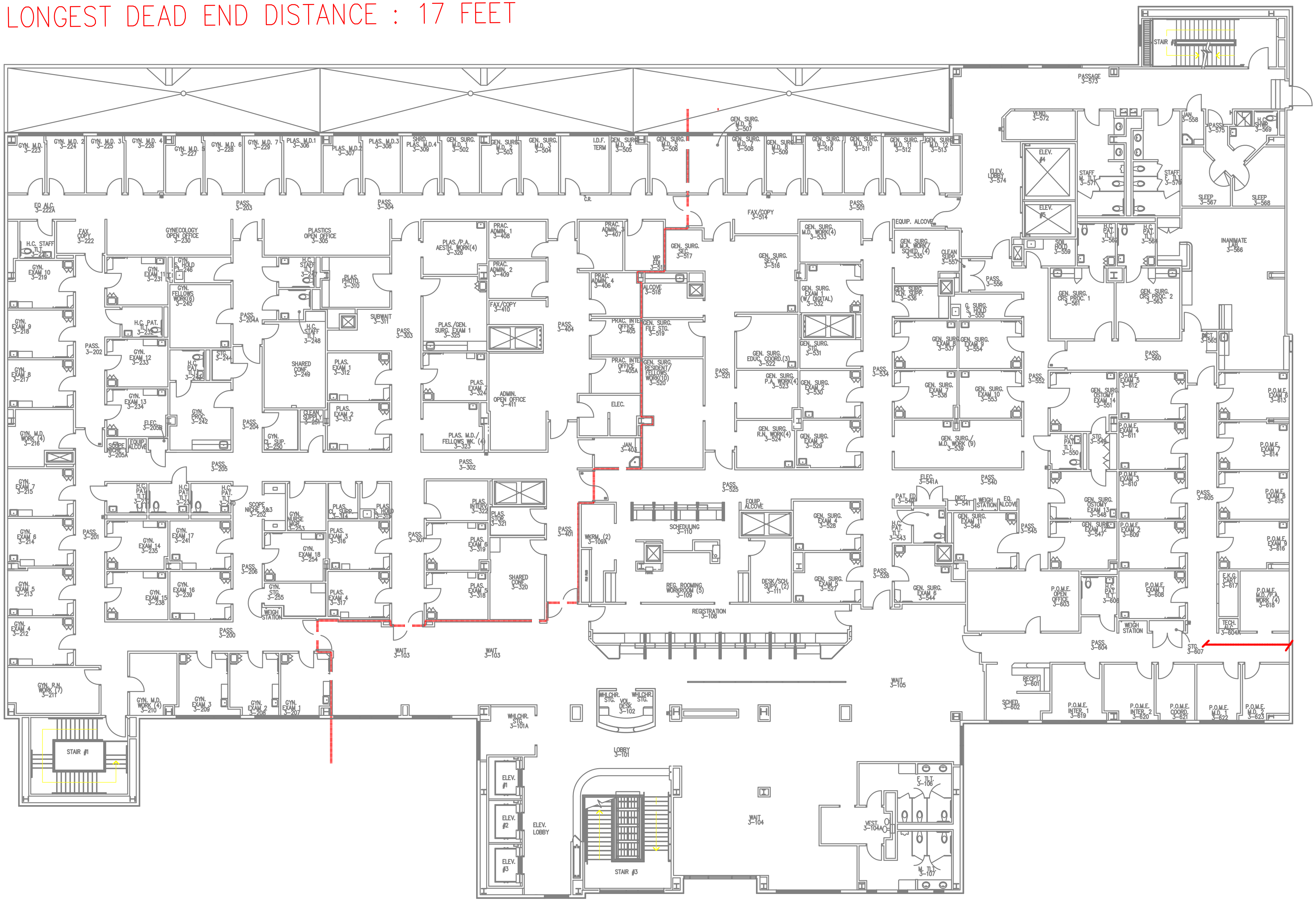
SECOND FLOOR

LONGEST DEAD END DISTANCE : 50 FEET



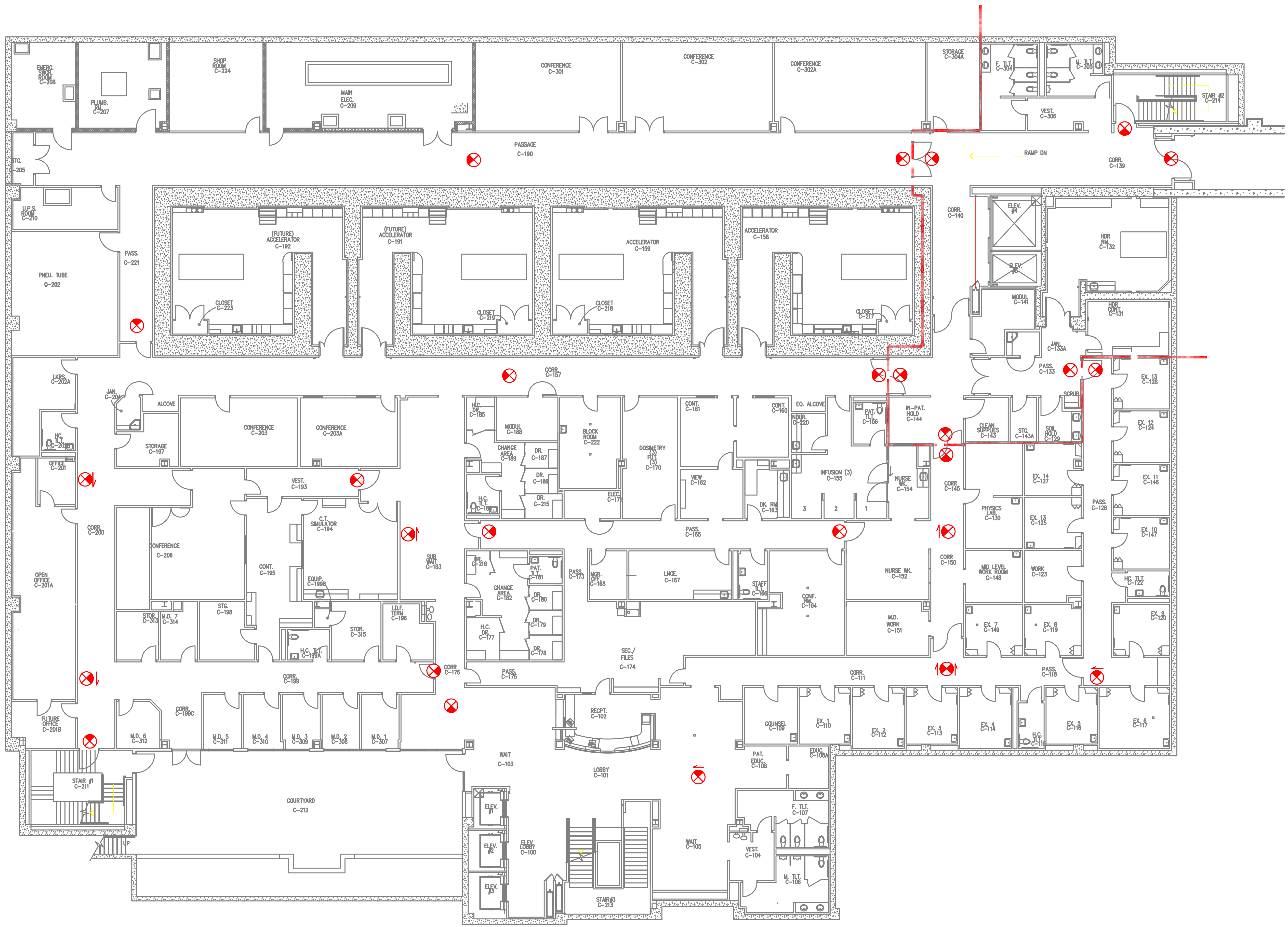
THIRD FLOOR

LONGEST DEAD END DISTANCE : 17 FEET

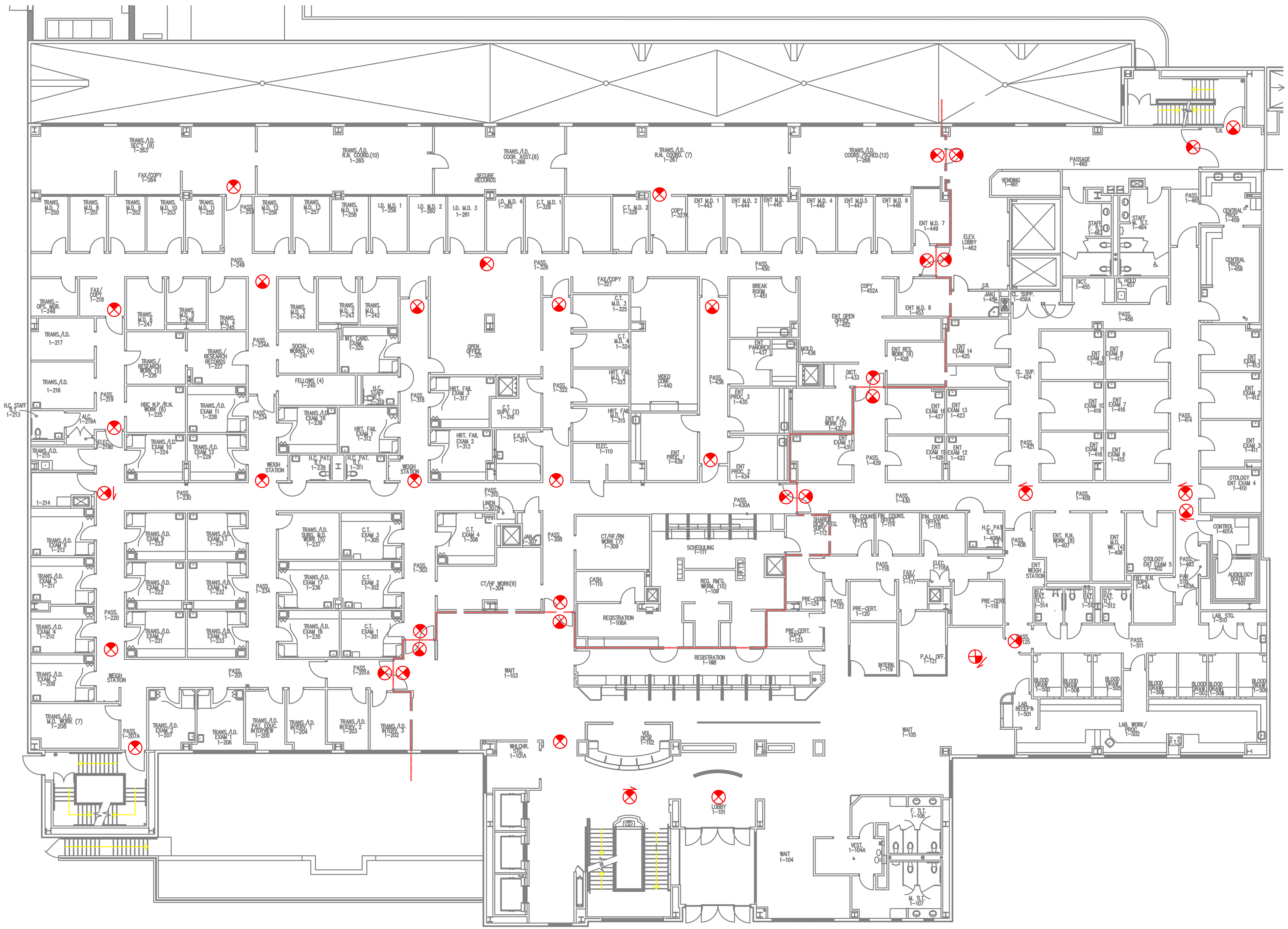


Appendix O

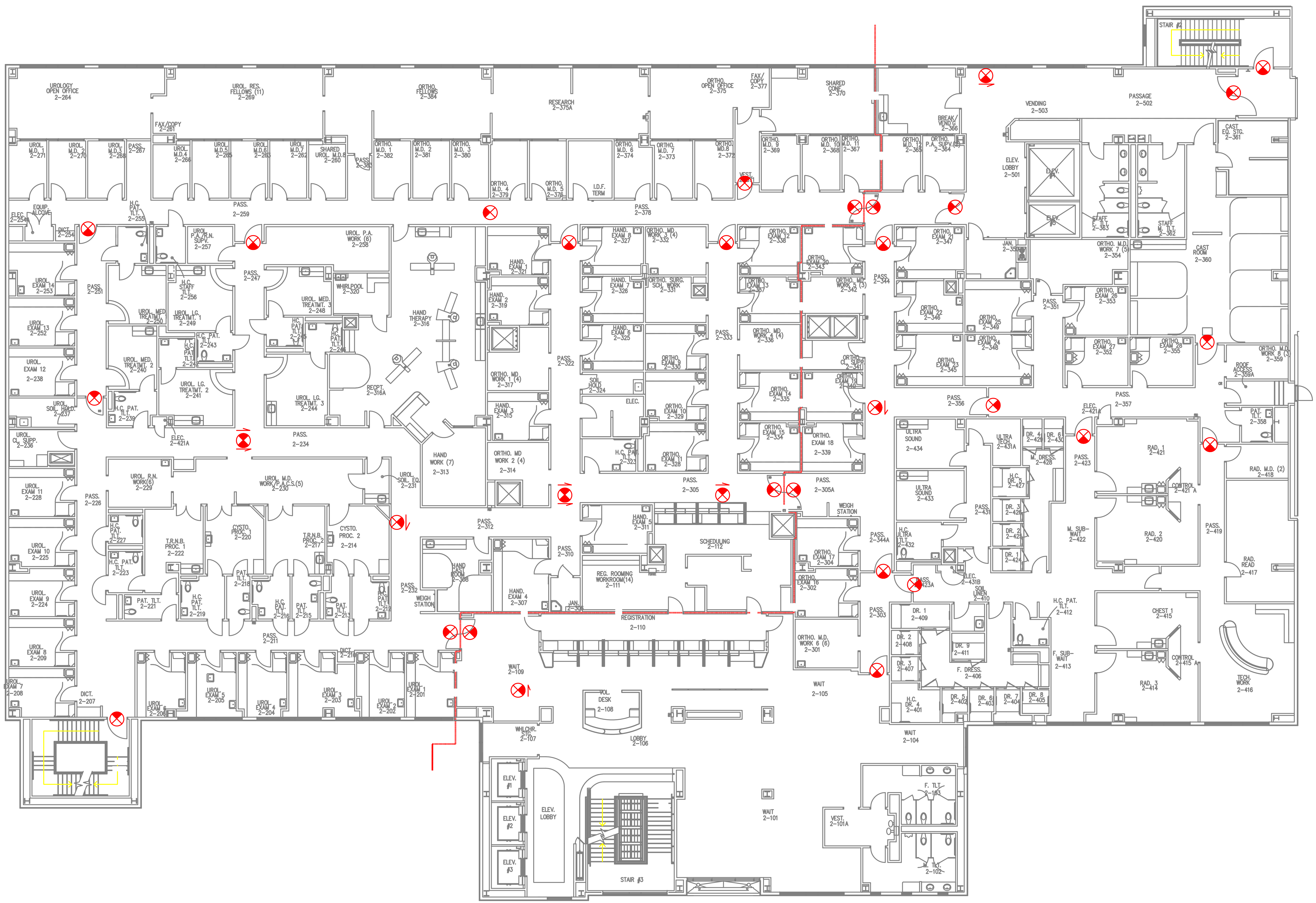
CONCOURSE FLOOR



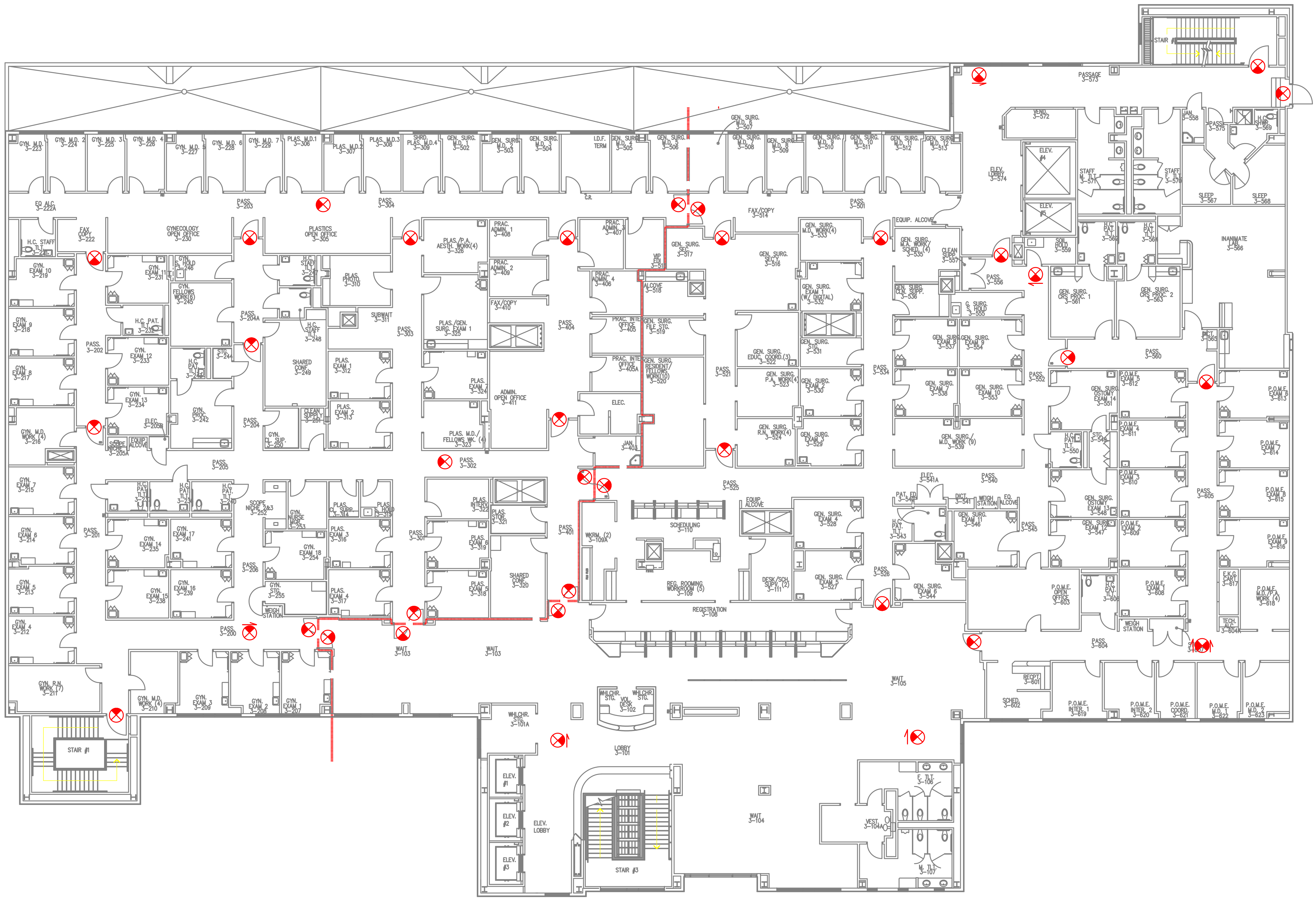
FIRST FLOOR



SECOND FLOOR

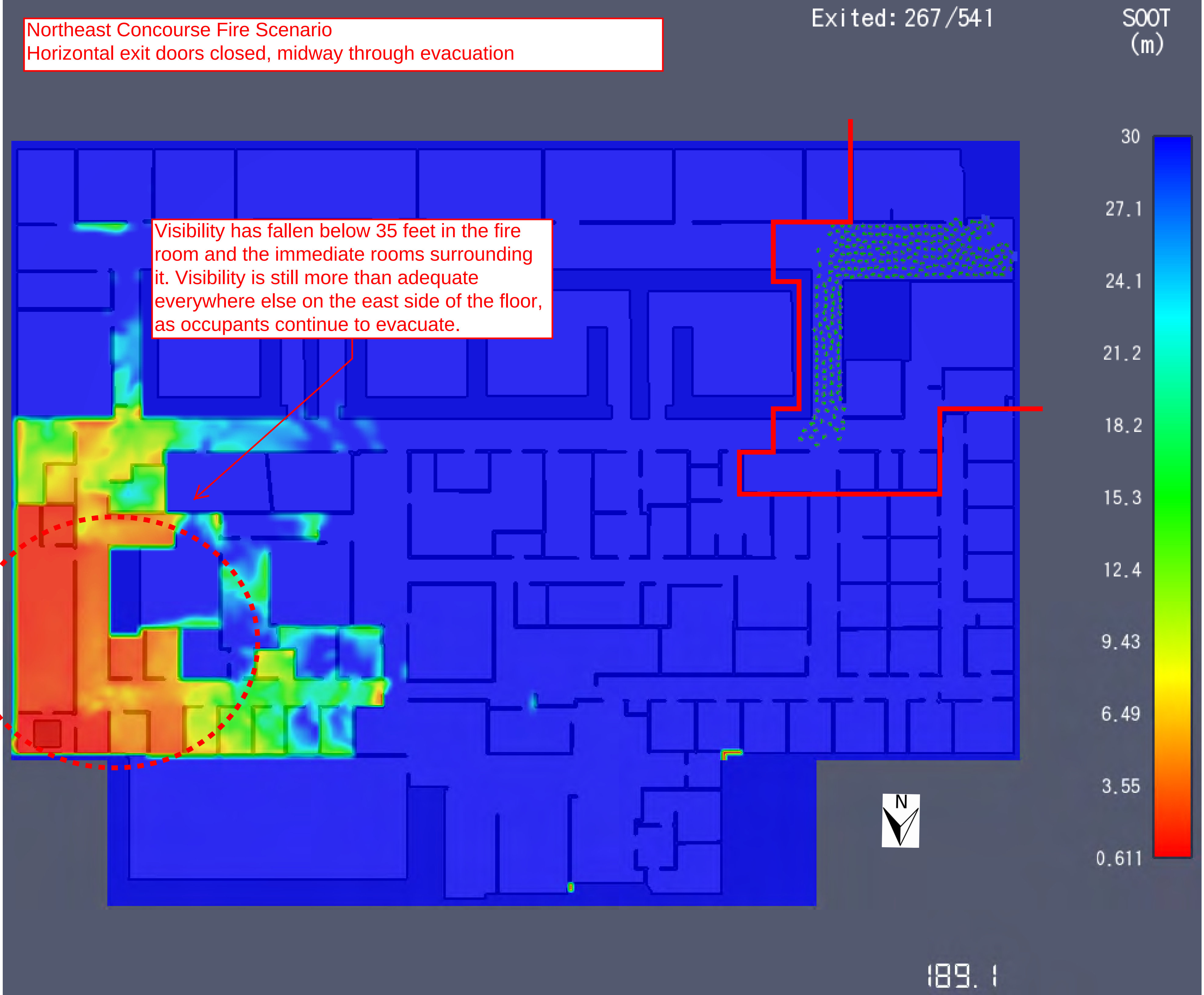


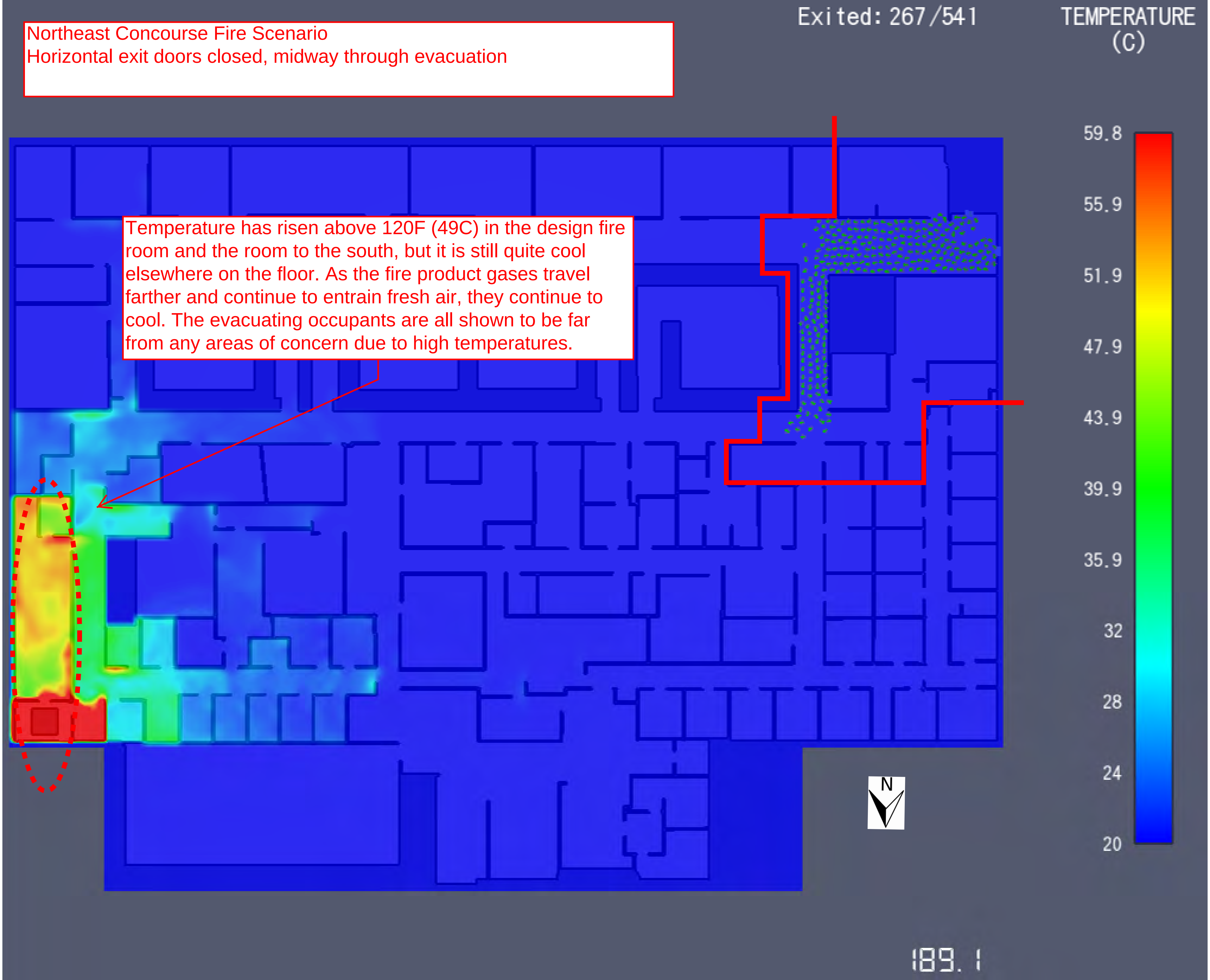
THIRD FLOOR



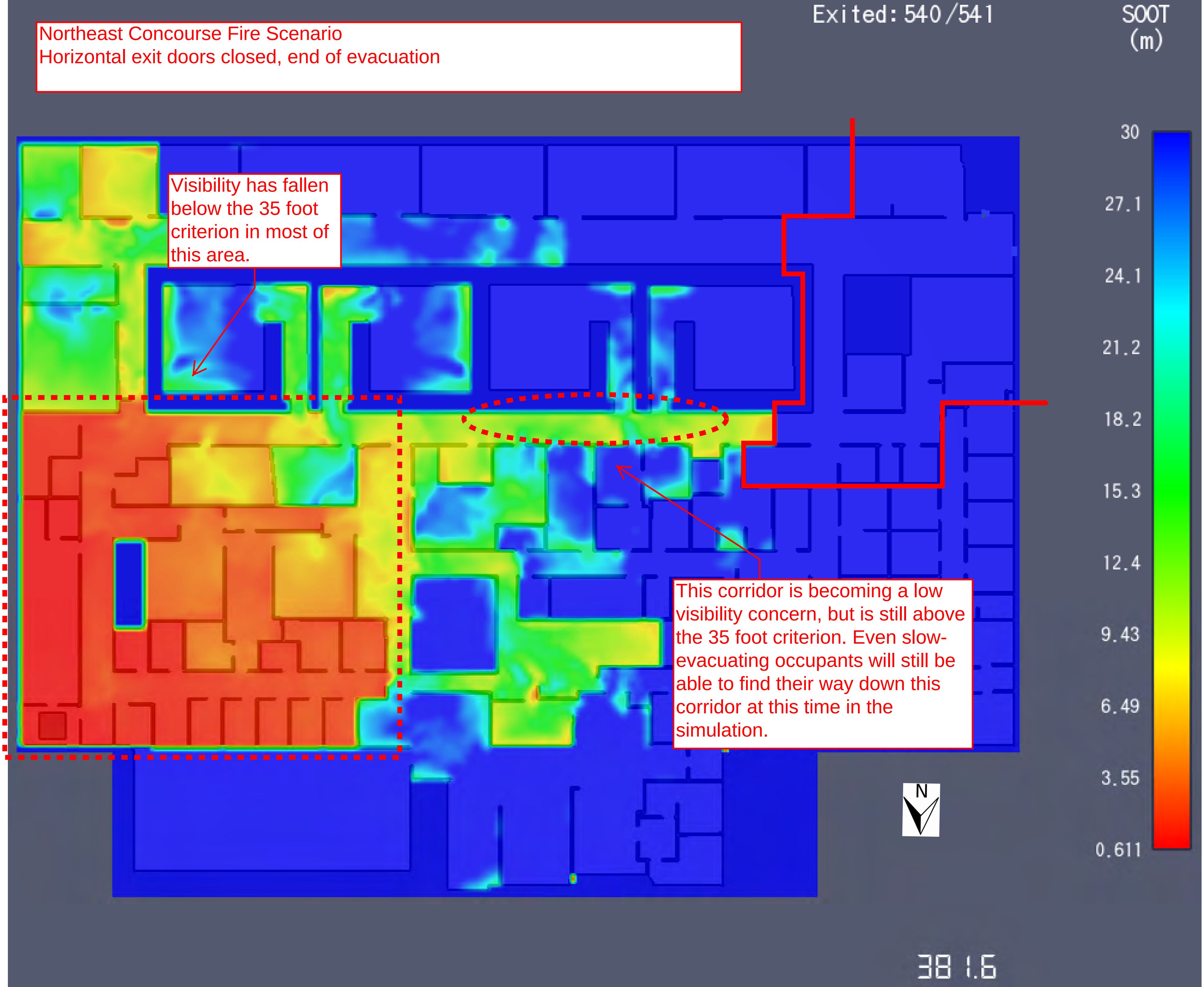
Appendix P

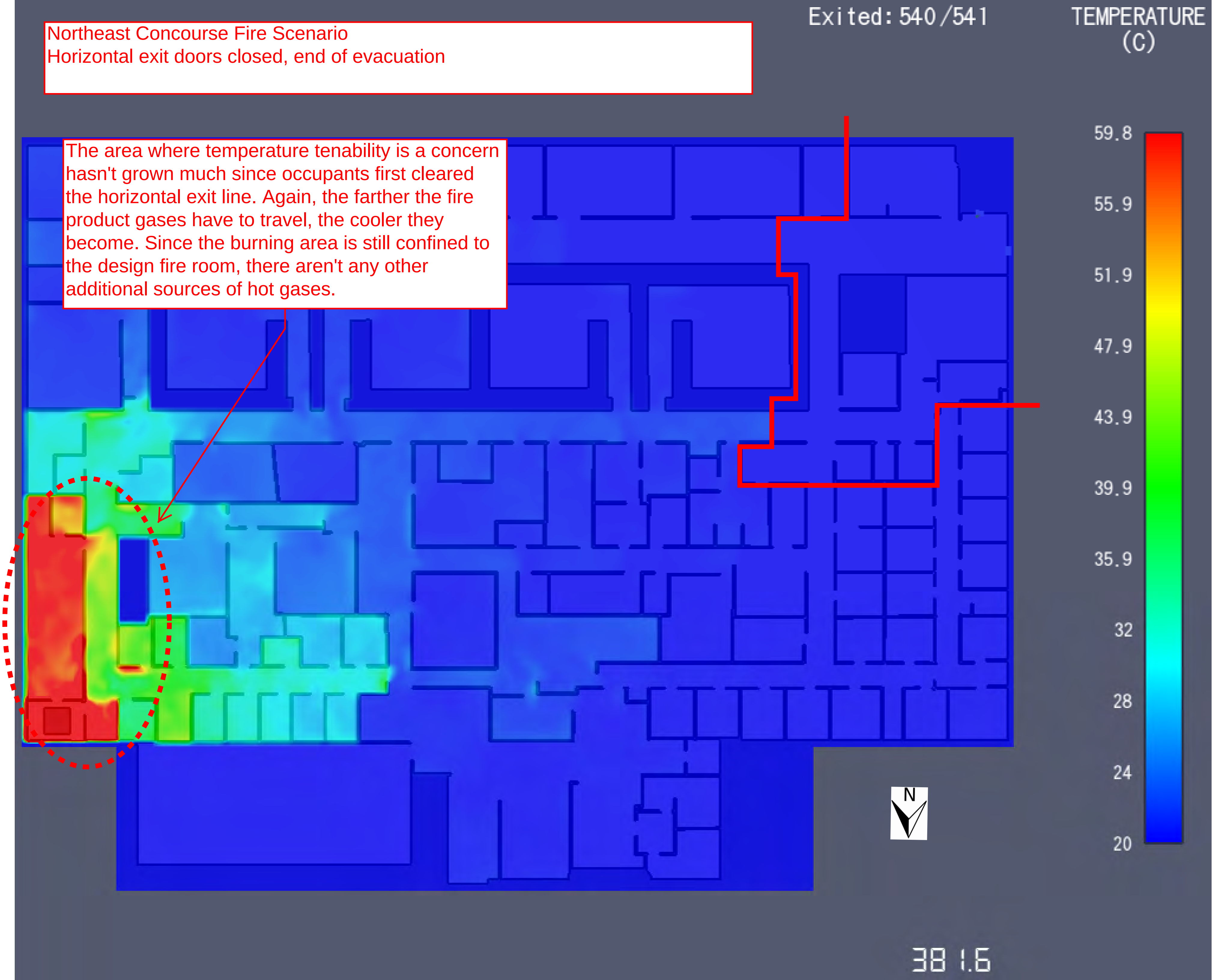
Northeast Concourse Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 267/541
CARBON
(mol/mol)
Horizontal exit line
Even the worst areas have not reached the toxic limit of 0.0015
0.000209
0.000188
0.000167
0.000146
0.000125
0.000104
8.34e-005
6.26e-005
4.17e-005
2.09e-005
0
Design fire location
N
189.1


Northeast Concourse Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 267/541
SOOT
(m)
30
27.1
24.1
21.2
18.2
15.3
12.4
9.43
6.49
3.55
0.611
Visibility has fallen below 35 feet in the fire room and the immediate rooms surrounding it. Visibility is still more than adequate everywhere else on the east side of the floor, as occupants continue to evacuate.
N
189.1


Northeast Concourse Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 267/541
TEMPERATURE (C)
59.8
55.9
51.9
47.9
43.9
39.9
35.9
32
28
24
20
Temperature has risen above 120F (49C) in the design fire room and the room to the south, but it is still quite cool elsewhere on the floor. As the fire product gases travel farther and continue to entrain fresh air, they continue to cool. The evacuating occupants are all shown to be far from any areas of concern due to high temperatures.
N
189.1

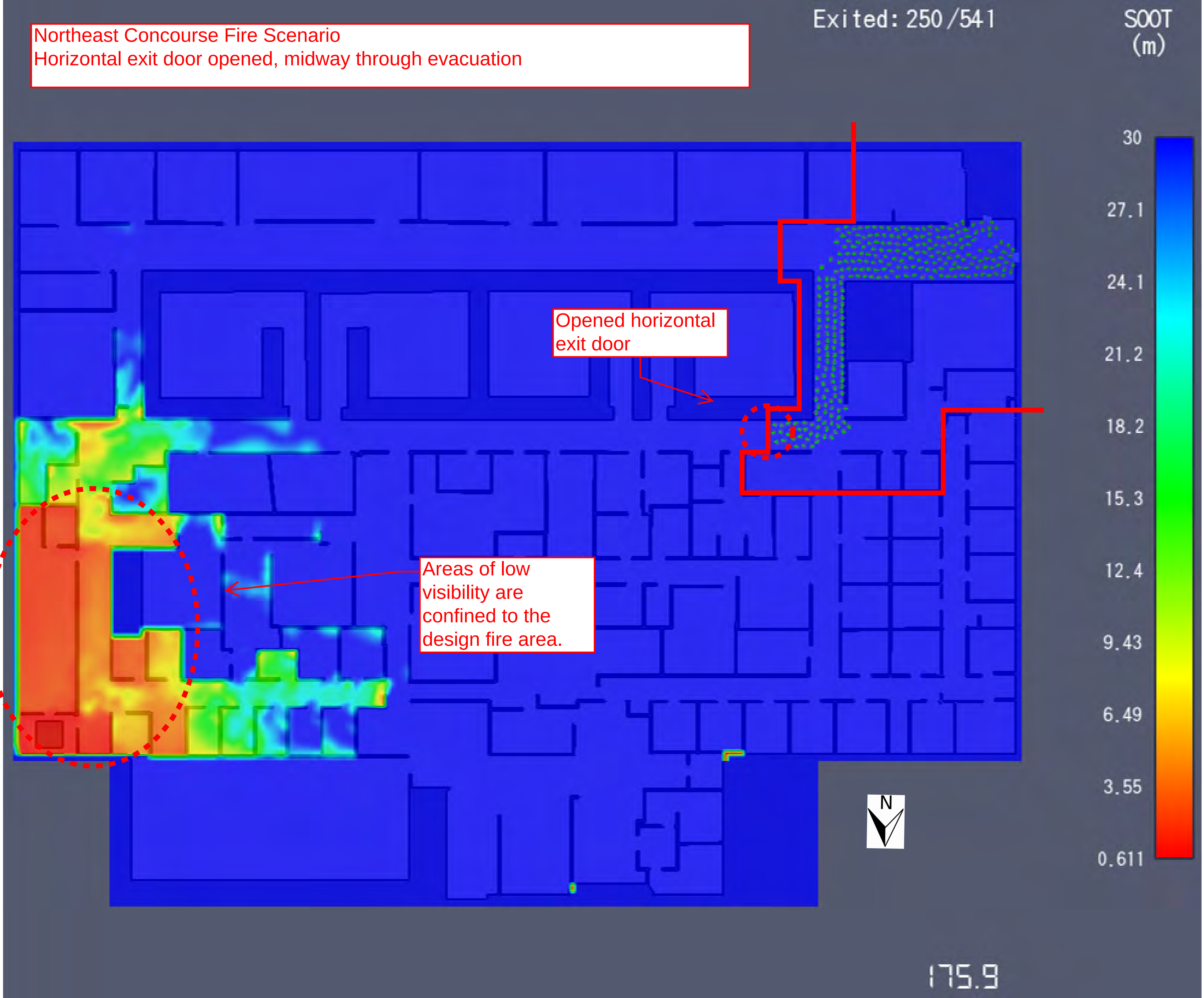

Northeast Concourse Fire Scenario
Horizontal exit doors closed, end of evacuation
Exited: 540/541
CARBON
(mol/mol)
The horizontal exit doors are all closed in this simulation. Even so, CO toxicity is not a concern on the west side of the horizontal exit since the concentrations do not reach dangerous levels, even near the fire area.
0.000209
0.000188
0.000167
0.000146
0.000125
0.000104
8.34e-005
6.26e-005
4.17e-005
2.09e-005
0
N
381.6


Exited: 540/541
SOOT (m)
Northeast Concourse Fire Scenario
Horizontal exit doors closed, end of evacuation
Visibility has fallen below the 35 foot criterion in most of this area.
This corridor is becoming a low visibility concern, but is still above the 35 foot criterion. Even slow-evacuating occupants will still be able to find their way down this corridor at this time in the simulation.
30
27.1
24.1
21.2
18.2
15.3
12.4
9.43
6.49
3.55
0.611
N
381.6

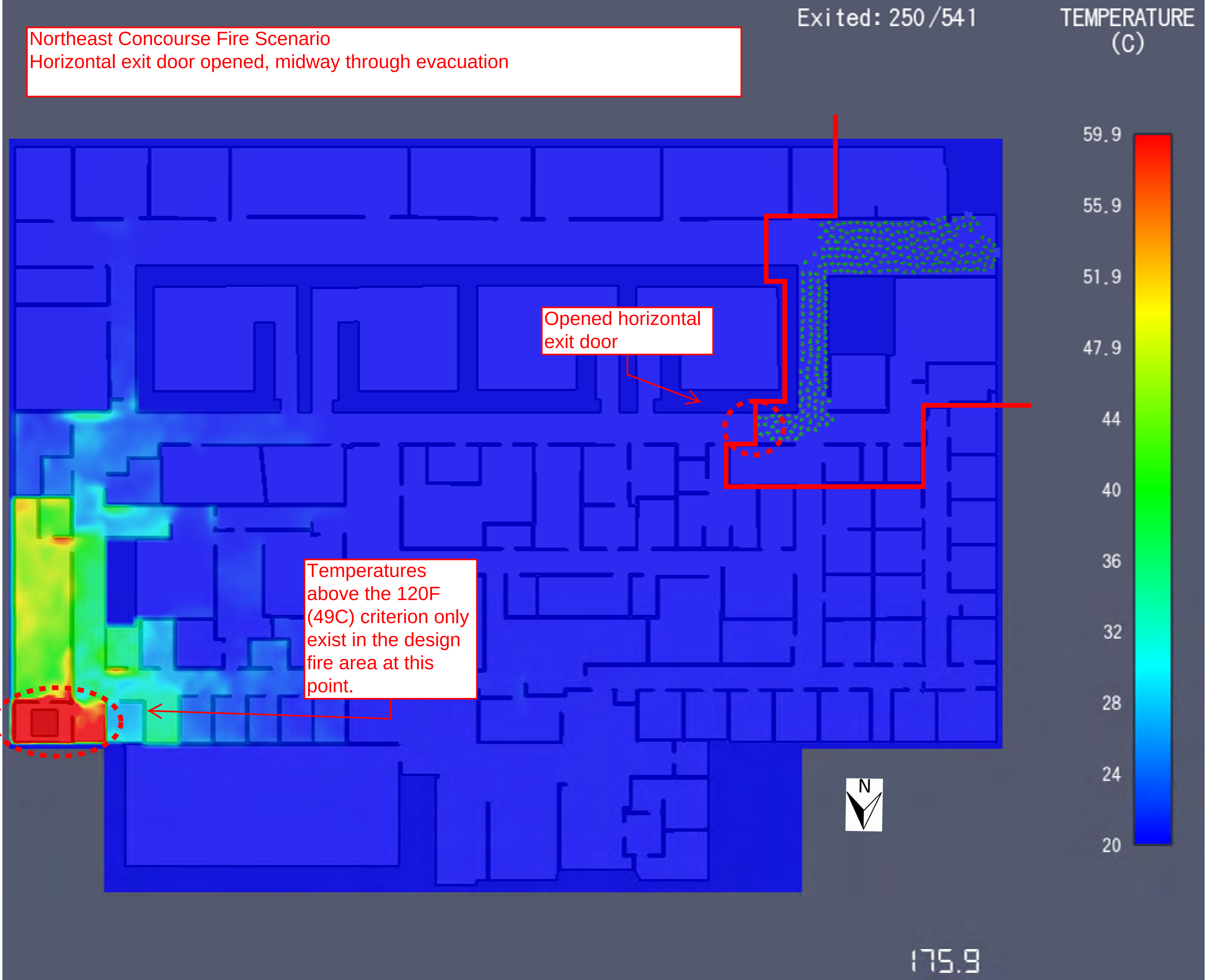


Northeast Concourse Fire Scenario
Horizontal exit doors closed, end of evacuation
Exited: 540/541
TEMPERATURE (C)
The area where temperature tenability is a concern hasn't grown much since occupants first cleared the horizontal exit line. Again, the farther the fire product gases have to travel, the cooler they become. Since the burning area is still confined to the design fire room, there aren't any other additional sources of hot gases.
59.8
55.9
51.9
47.9
43.9
39.9
35.9
32
28
24
20
N
3811.6

Northeast Concourse Fire Scenario
Horizontal exit door opened, midway through evacuation
Exited: 250/541
CARBON
(mol/mol)
0.00021
0.000189
0.000168
0.000147
0.000126
0.000105
8.38e-005
6.29e-005
4.19e-005
2.1e-005
0
Opened horizontal exit door
CO toxicity is mainly a concern only in the room of fire origin, even after all occupants have moved to the other side of the floor-dividing horizontal exit.
N
175.9

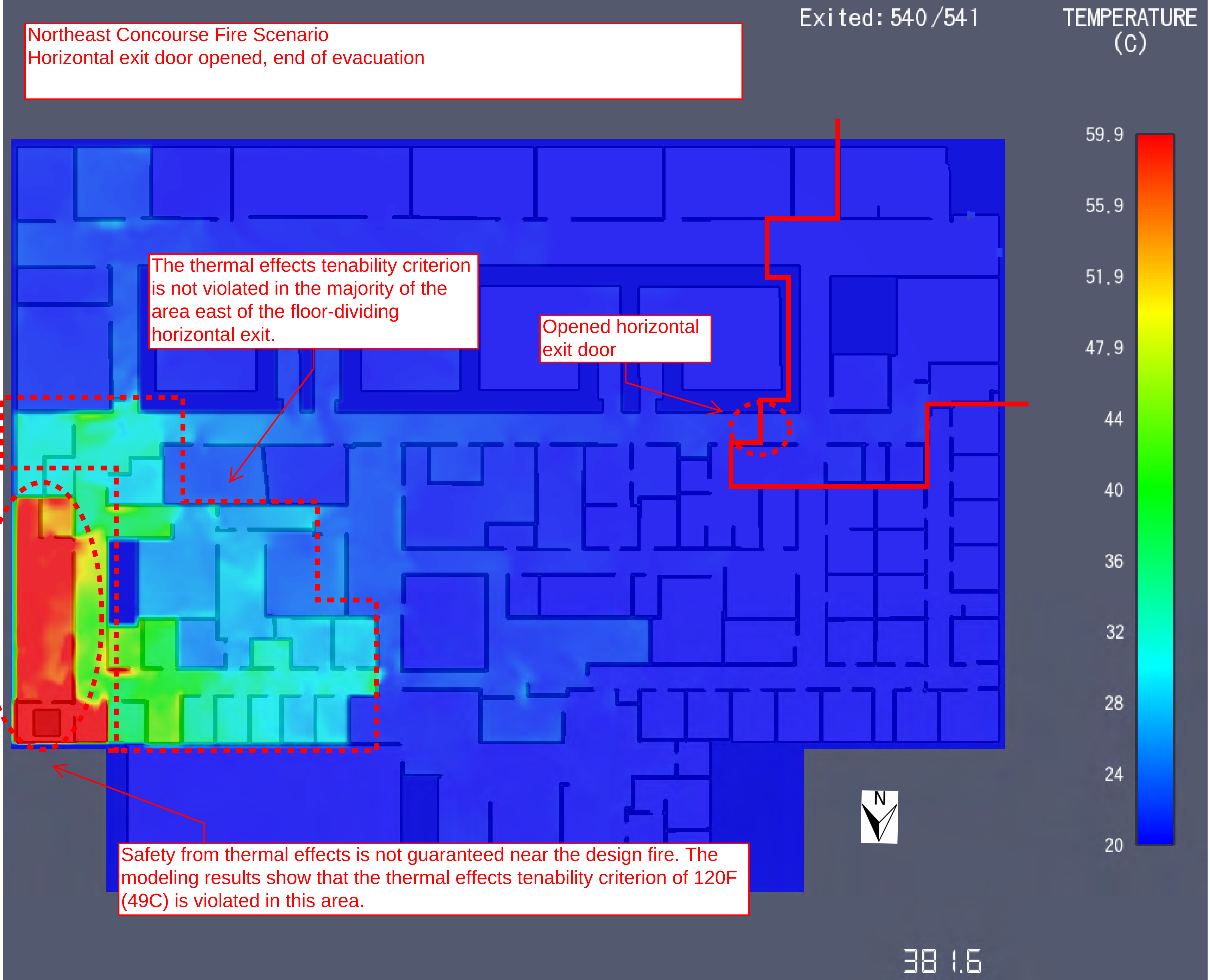


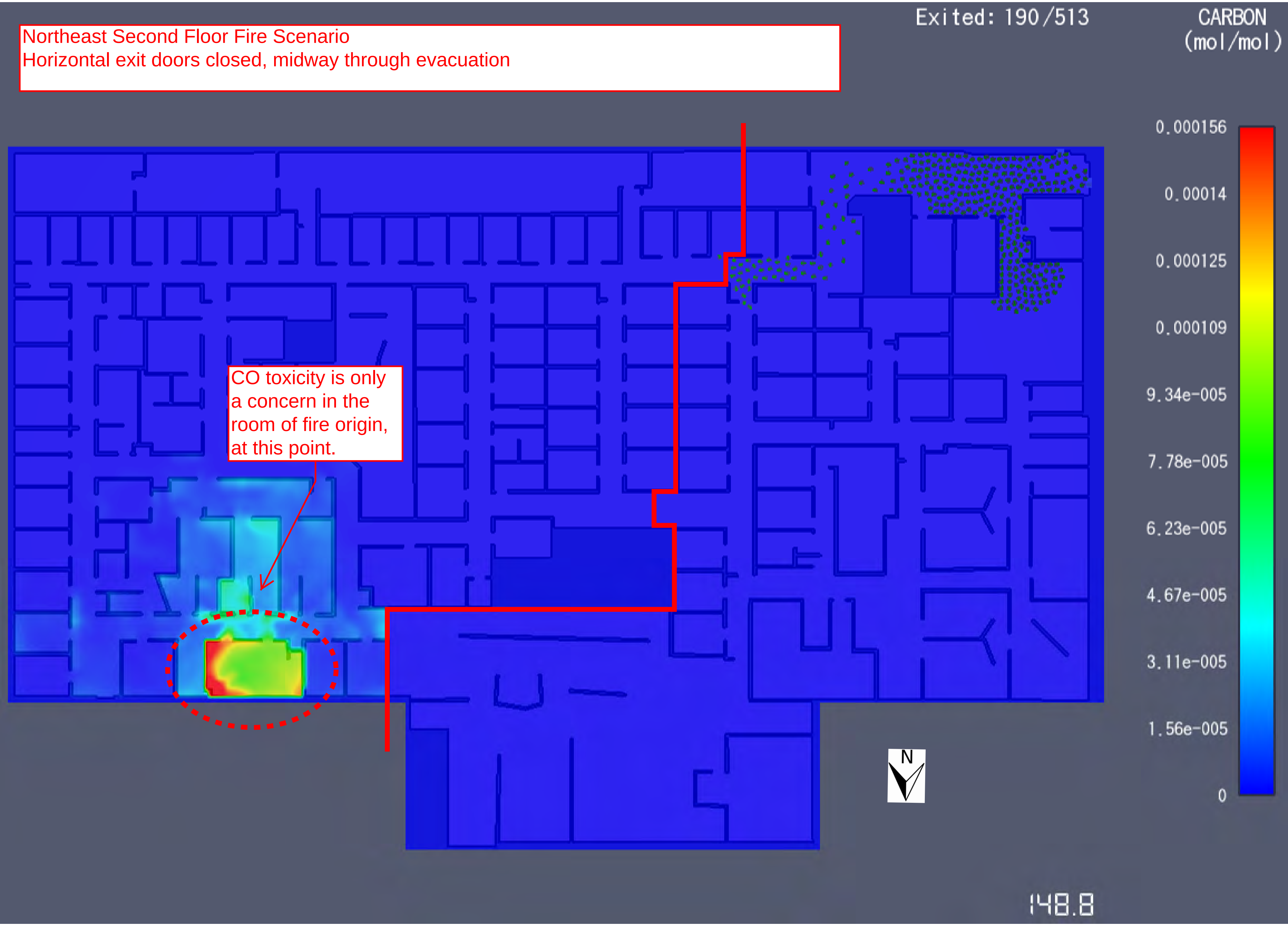
Northeast Concourse Fire Scenario
Horizontal exit door opened, midway through evacuation
Exited: 250 / 541
SOOT
(m)
30
27.1
24.1
21.2
18.2
15.3
12.4
9.43
6.49
3.55
0.611
Opened horizontal exit door
Areas of low visibility are confined to the design fire area.
N
175.9

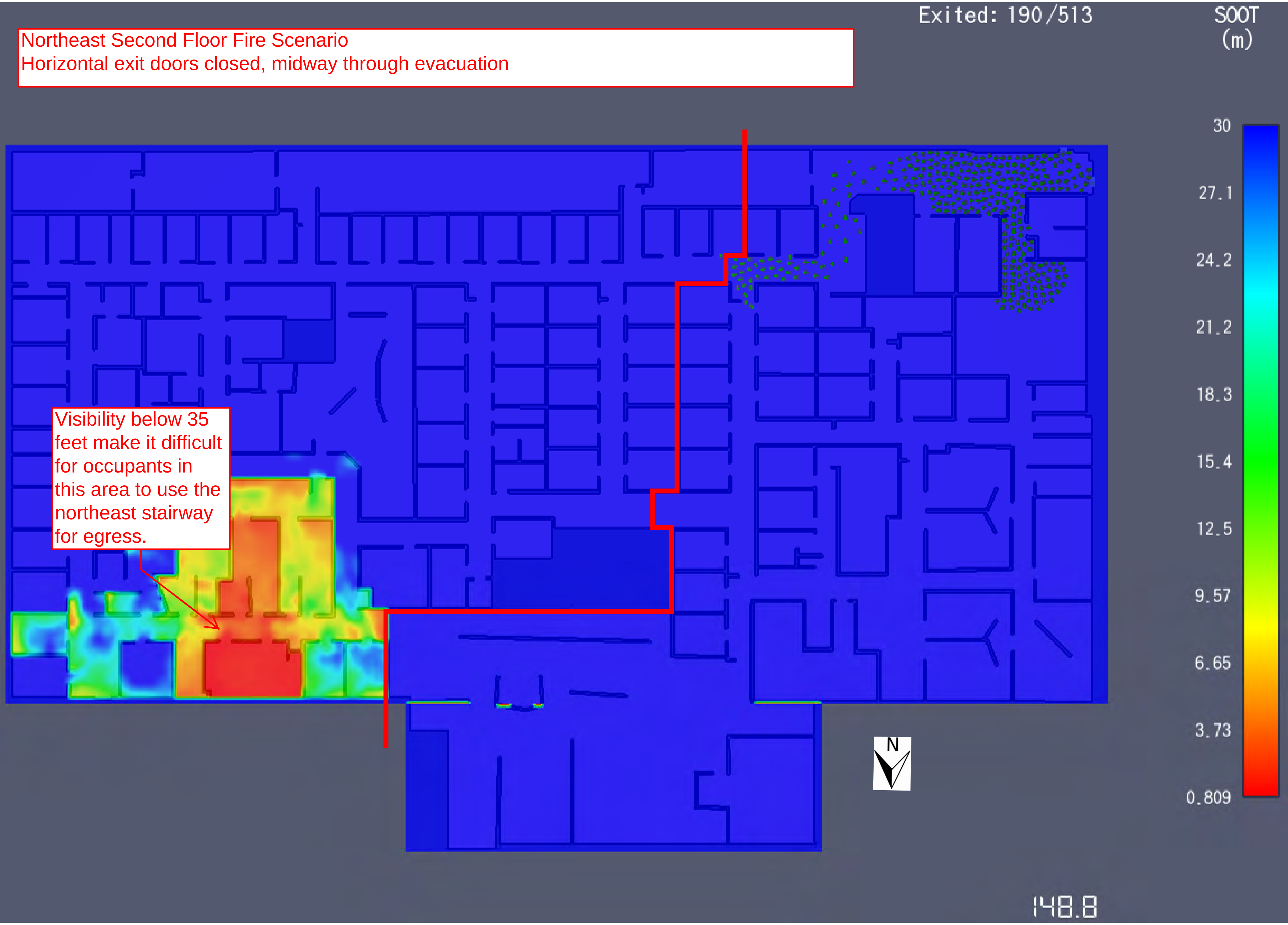

Northeast Concourse Fire Scenario
Horizontal exit door opened, midway through evacuation
Exited: 250 /541
TEMPERATURE (C)
59.9
55.9
51.9
47.9
44
40
36
32
28
24
20
Opened horizontal exit door
Temperatures above the 120F (49C) criterion only exist in the design fire area at this point.
N
175.9

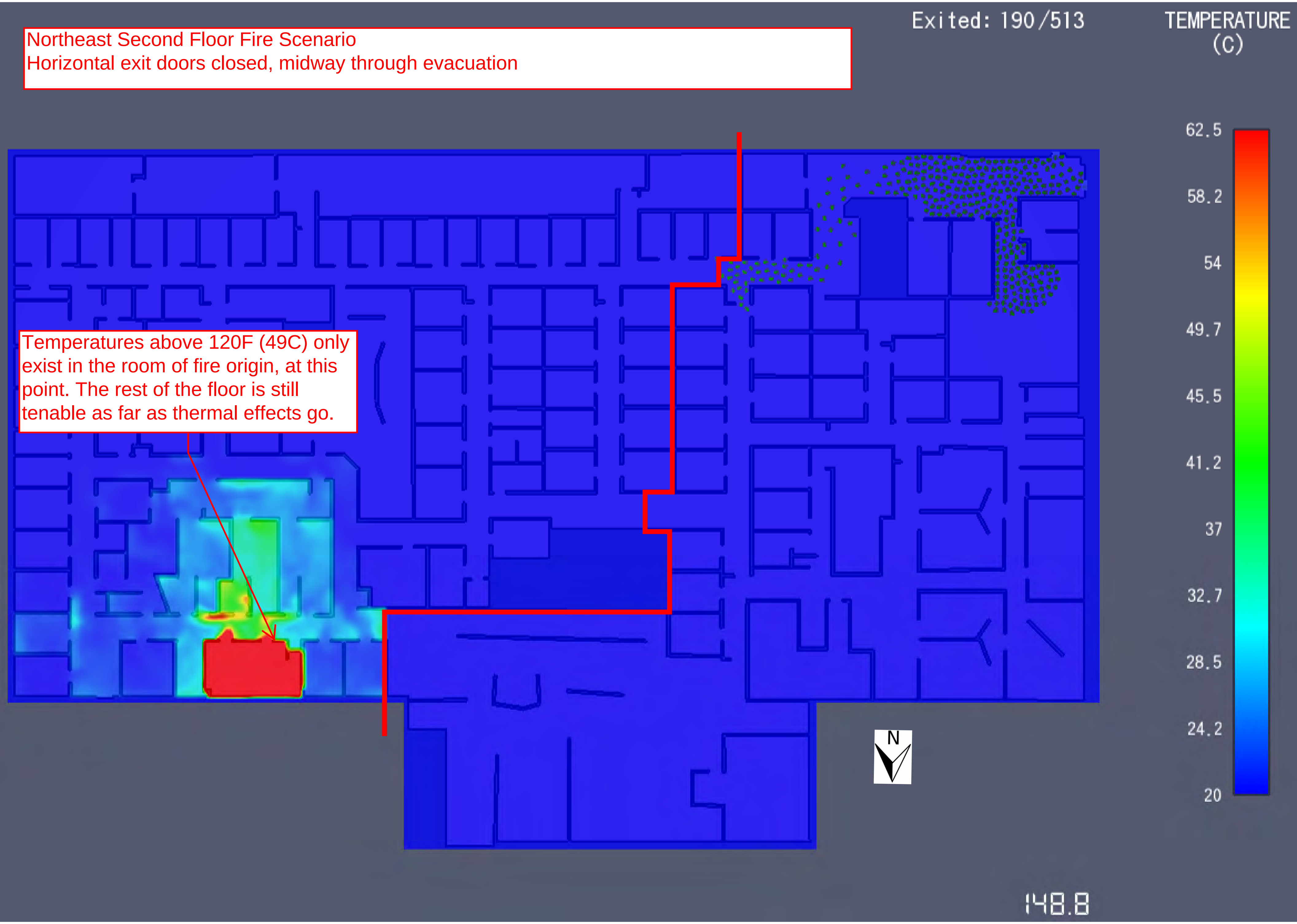

Northeast Concourse Fire Scenario
Horizontal exit door opened, end of evacuation
Exited: 540/541
CARBON
(mol/mol)
0.00021
0.000189
0.000168
0.000147
0.000126
0.000105
8.38e-005
6.29e-005
4.19e-005
2.1e-005
0
Opened horizontal exit door
N
381.6

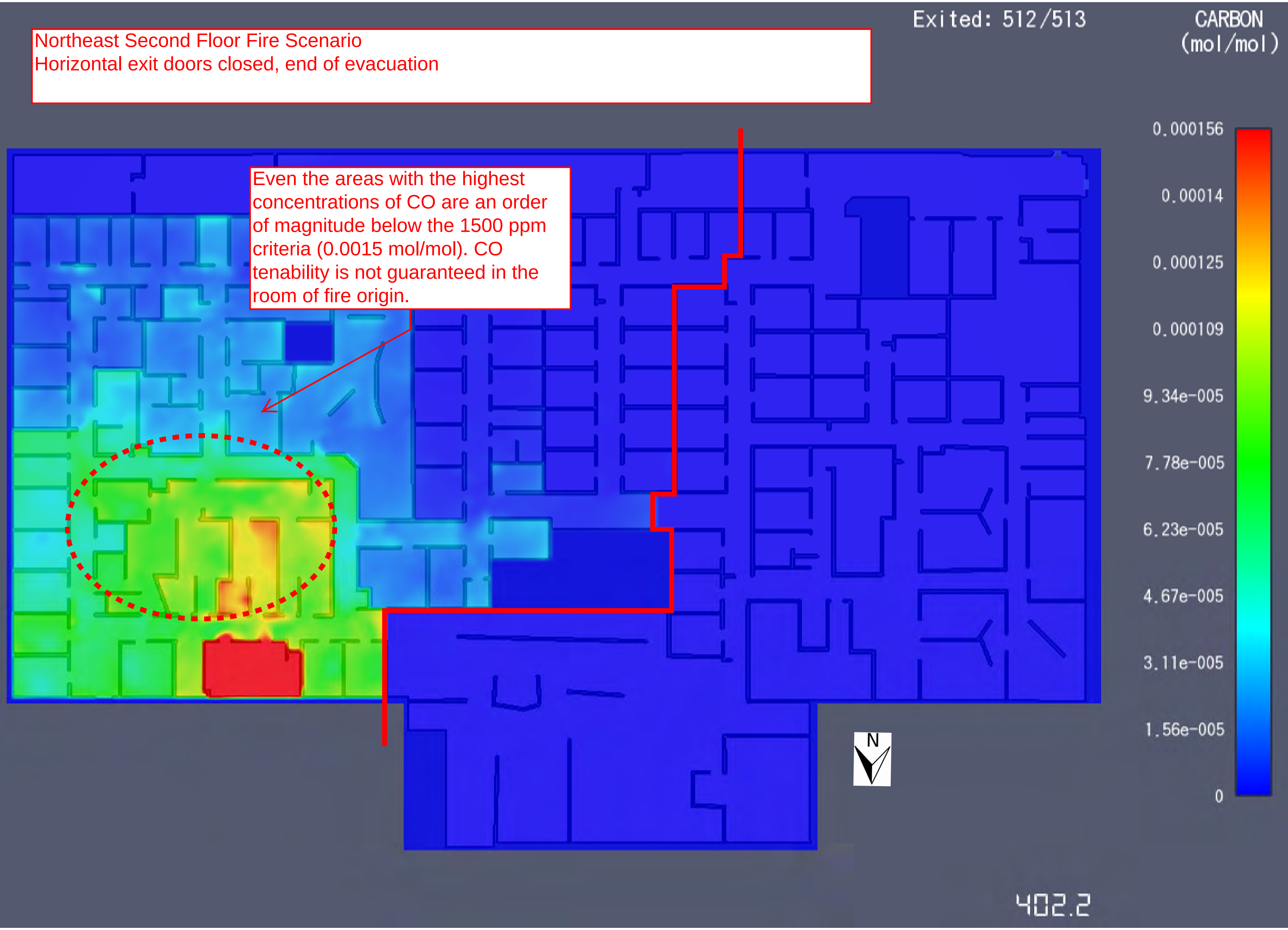
Northeast Concourse Fire Scenario
Horizontal exit door opened, end of evacuation
Exited: 540/541
SOOT
(m)
30
27.1
24.1
21.2
18.2
15.3
12.4
9.43
6.49
3.55
0.611
Opened horizontal exit door
Even though the horizontal exit door is opened in this model, low visibility conditions still do not exist on the other side of the horizontal exit. Visibility in this corridor is also still above the 35 foot criterion.
N
381.6

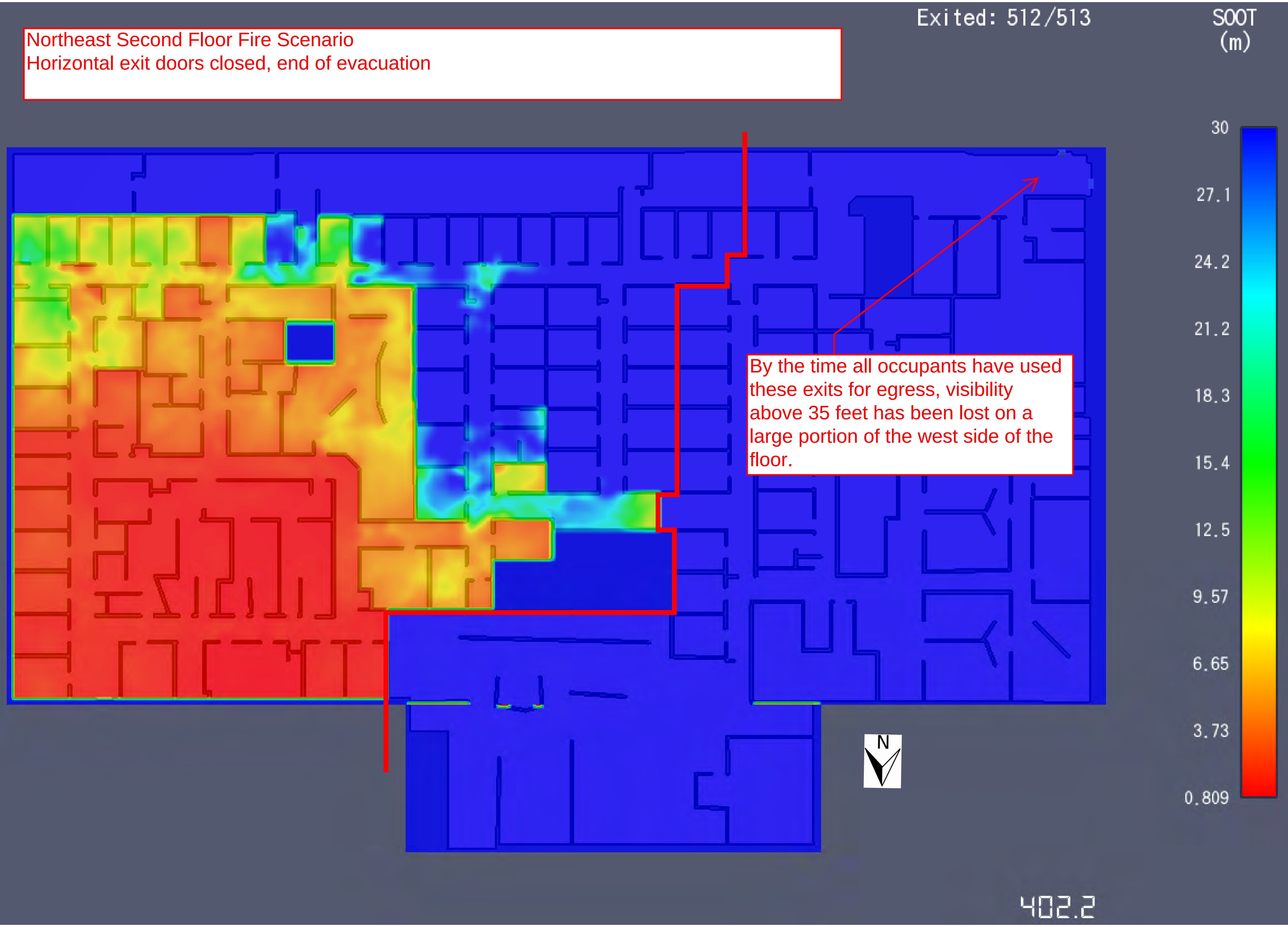

Northeast Concourse Fire Scenario
Horizontal exit door opened, end of evacuation
Exited: 540/541
TEMPERATURE (C)
59.9
55.9
51.9
47.9
44
40
36
32
28
24
20
The thermal effects tenability criterion is not violated in the majority of the area east of the floor-dividing horizontal exit.
Opened horizontal exit door
Safety from thermal effects is not guaranteed near the design fire. The modeling results show that the thermal effects tenability criterion of 120F (49C) is violated in this area.
N
381.6


Northeast Second Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 190/513
CARBON
(mol/mol)
0.000156
0.00014
0.000125
0.000109
9.34e-005
7.78e-005
6.23e-005
4.67e-005
3.11e-005
1.56e-005
0
CO toxicity is only a concern in the room of fire origin, at this point.
N
148.8

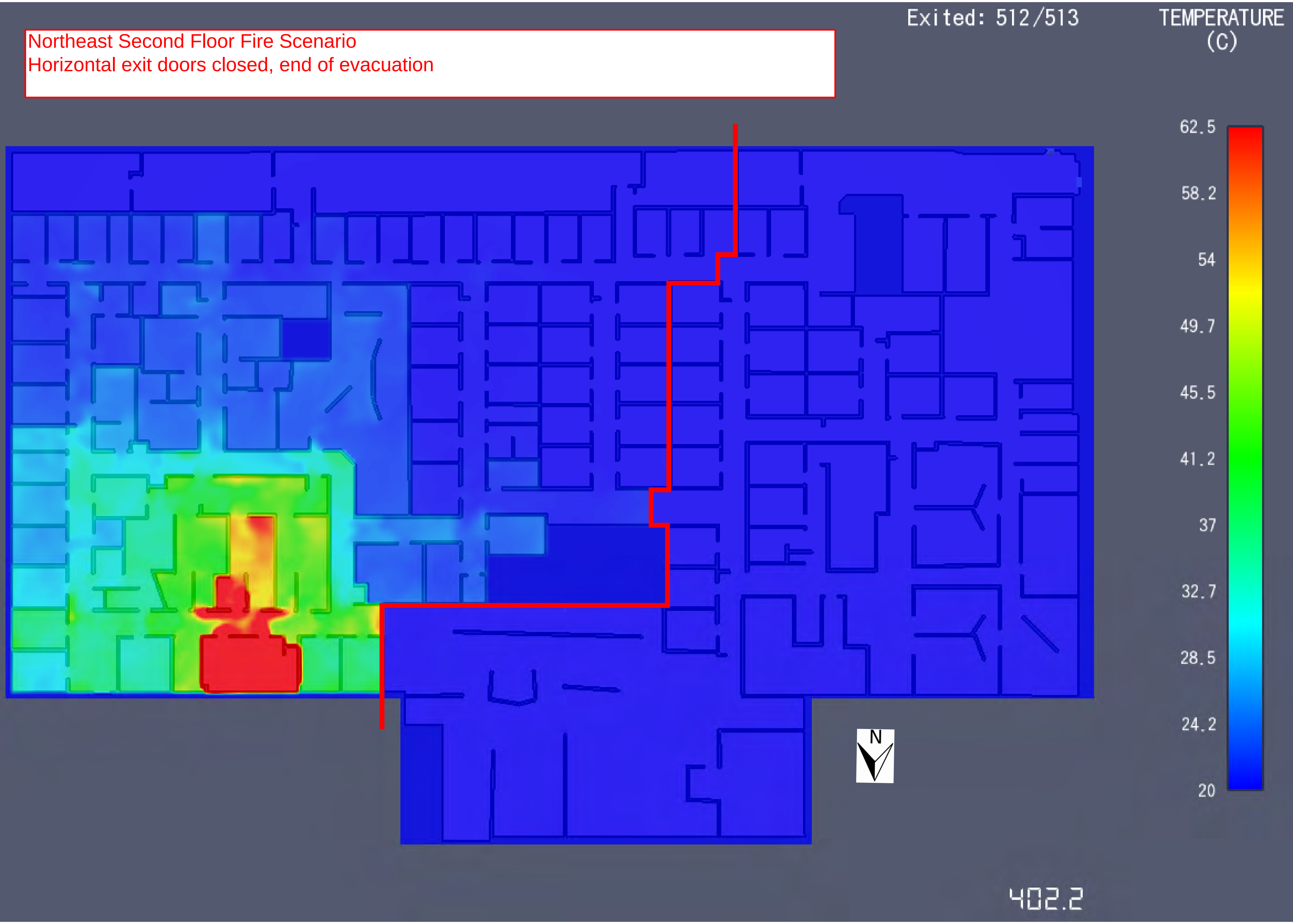

Northeast Second Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 190/513
SOOT
(m)
30
27.1
24.2
21.2
18.3
15.4
12.5
9.57
6.65
3.73
0.809
Visibility below 35 feet make it difficult for occupants in this area to use the northeast stairway for egress.
N
148.8


Northeast Second Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 190/513
TEMPERATURE
(C)
62.5
58.2
54
49.7
45.5
41.2
37
32.7
28.5
24.2
20
Temperatures above 120F (49C) only exist in the room of fire origin, at this point. The rest of the floor is still tenable as far as thermal effects go.
N
148.8


Northeast Second Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
Exited: 512/513
CARBON
(mol/mol)
0.000156
0.00014
0.000125
0.000109
9.34e-005
7.78e-005
6.23e-005
4.67e-005
3.11e-005
1.56e-005
0
Even the areas with the highest concentrations of CO are an order of magnitude below the 1500 ppm criteria (0.0015 mol/mol). CO tenability is not guaranteed in the room of fire origin.
N
402.2

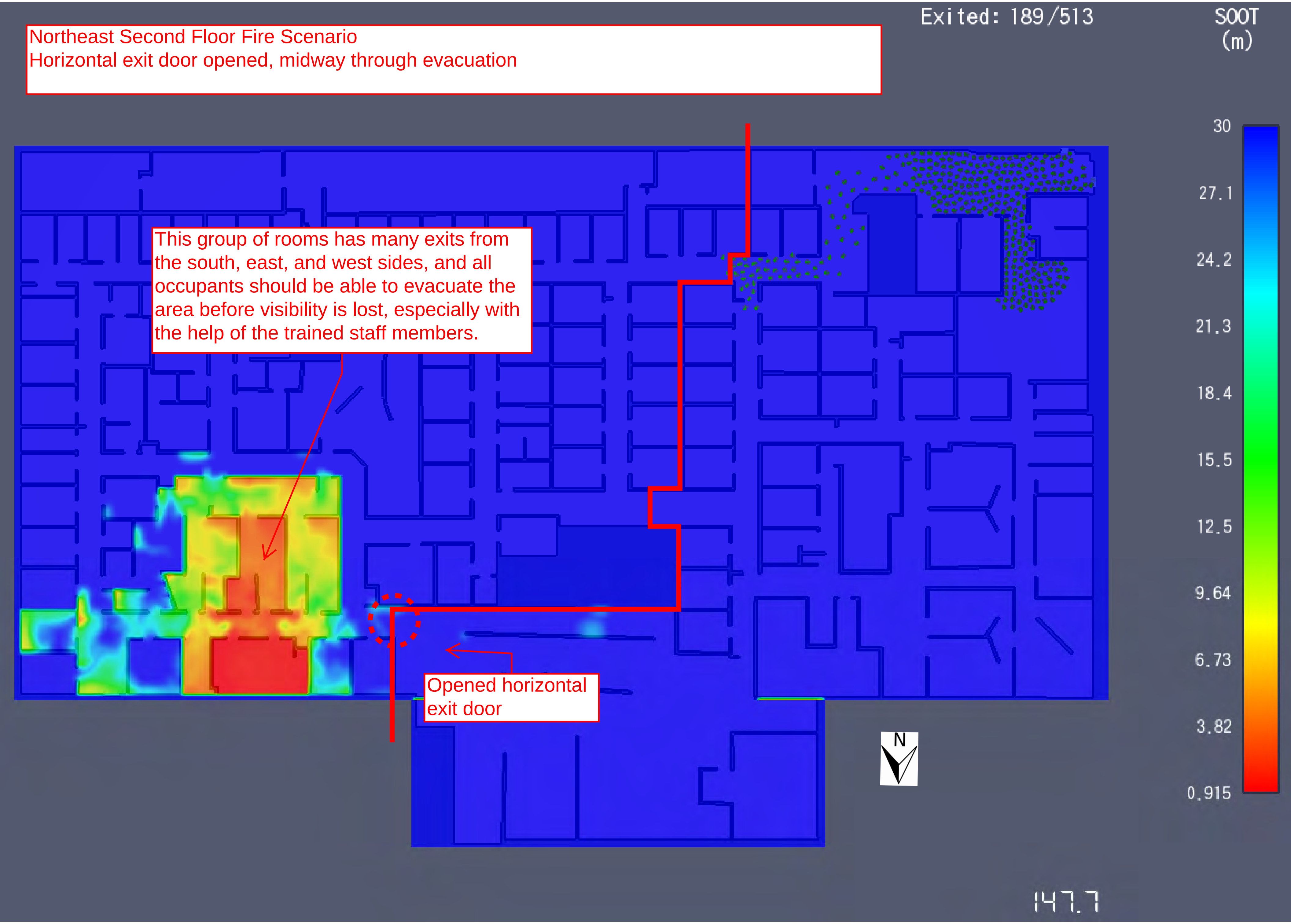


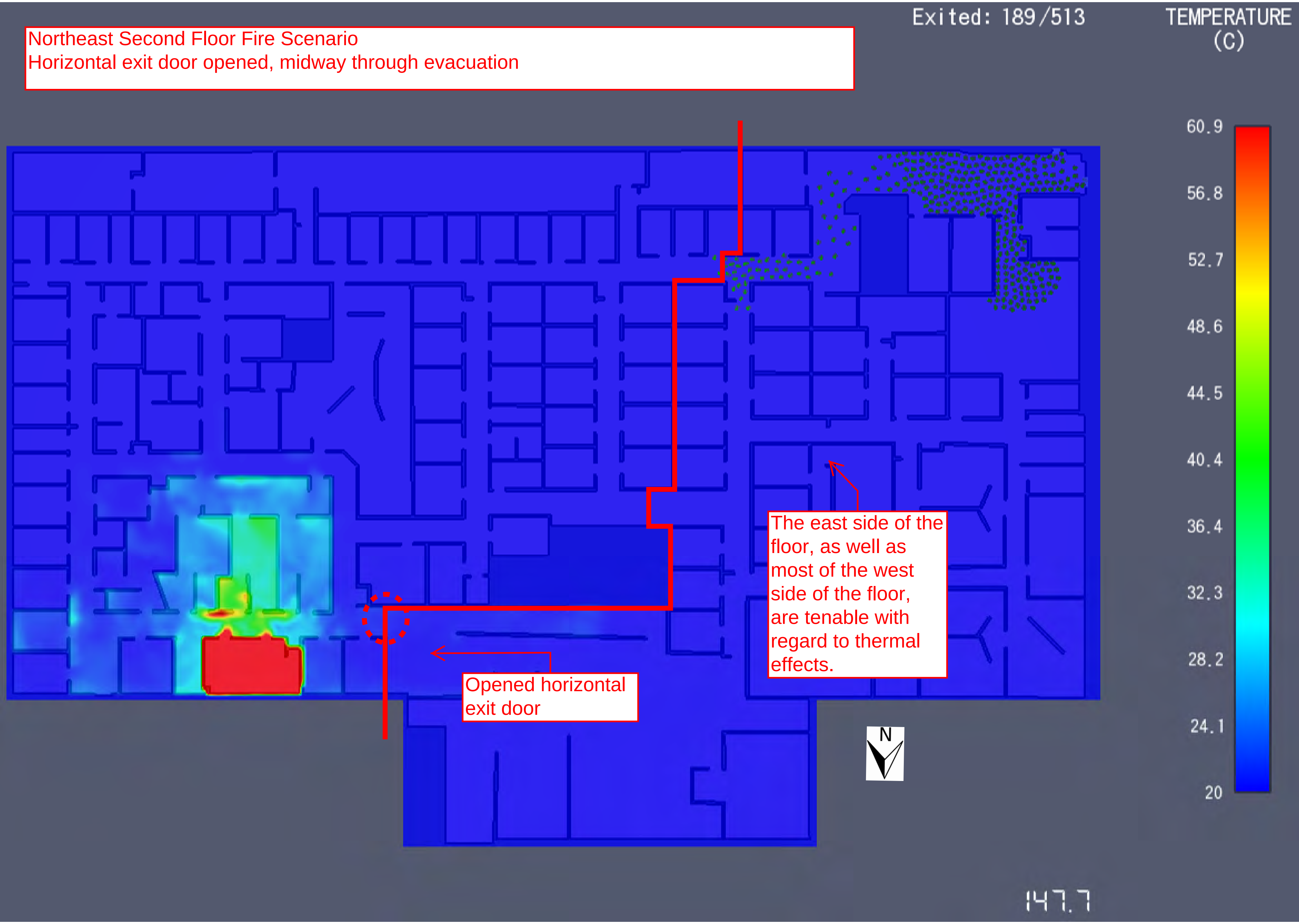
Northeast Second Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
Exited: 512/513
SOOT
(m)
30
27.1
24.2
21.2
18.3
15.4
12.5
9.57
6.65
3.73
0.809
By the time all occupants have used these exits for egress, visibility above 35 feet has been lost on a large portion of the west side of the floor.
N
402.2

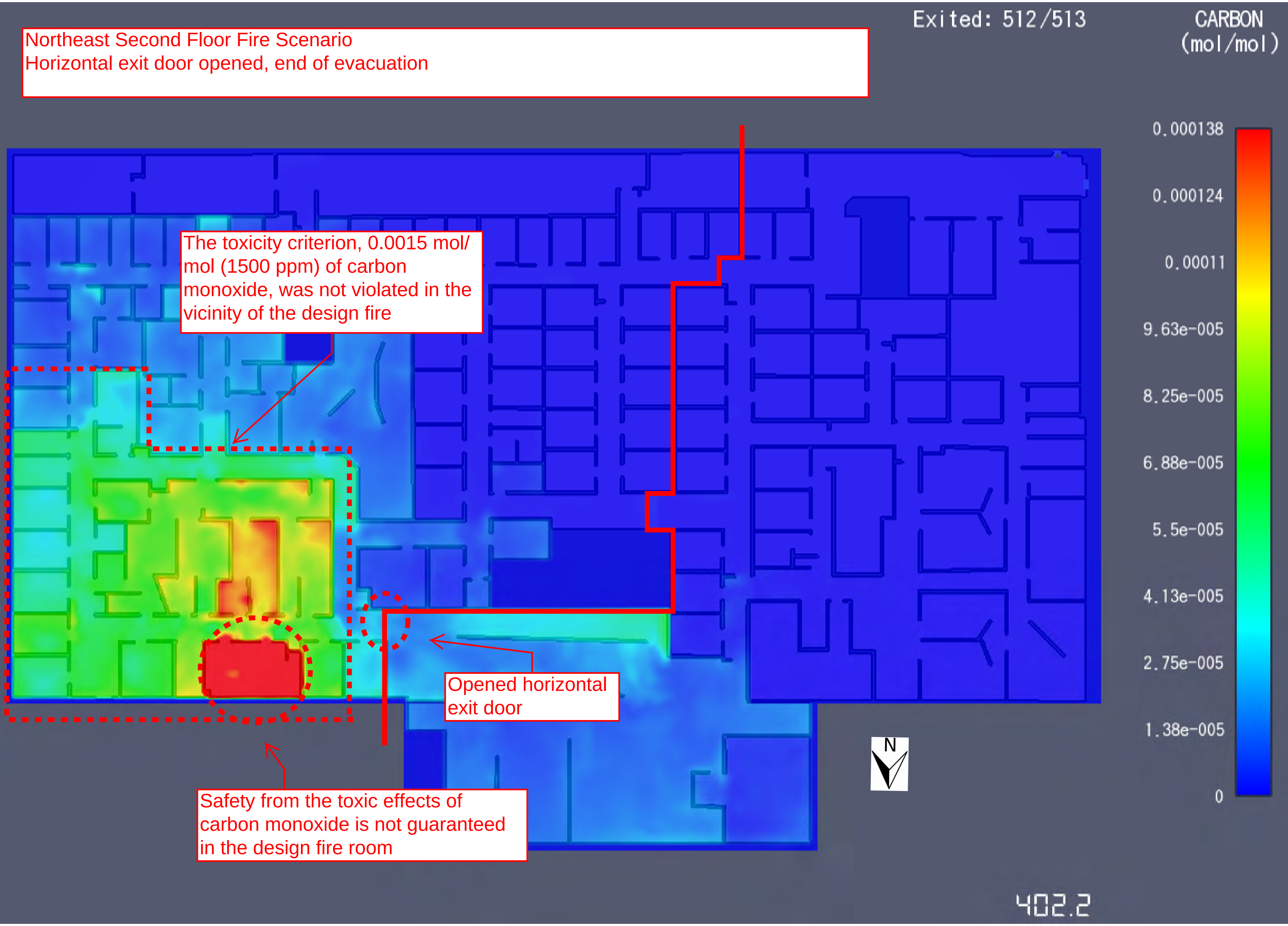


Northeast Second Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
Exited: 512/513
TEMPERATURE
(C)
62.5
58.2
54
49.7
45.5
41.2
37
32.7
28.5
24.2
20
N
402.2

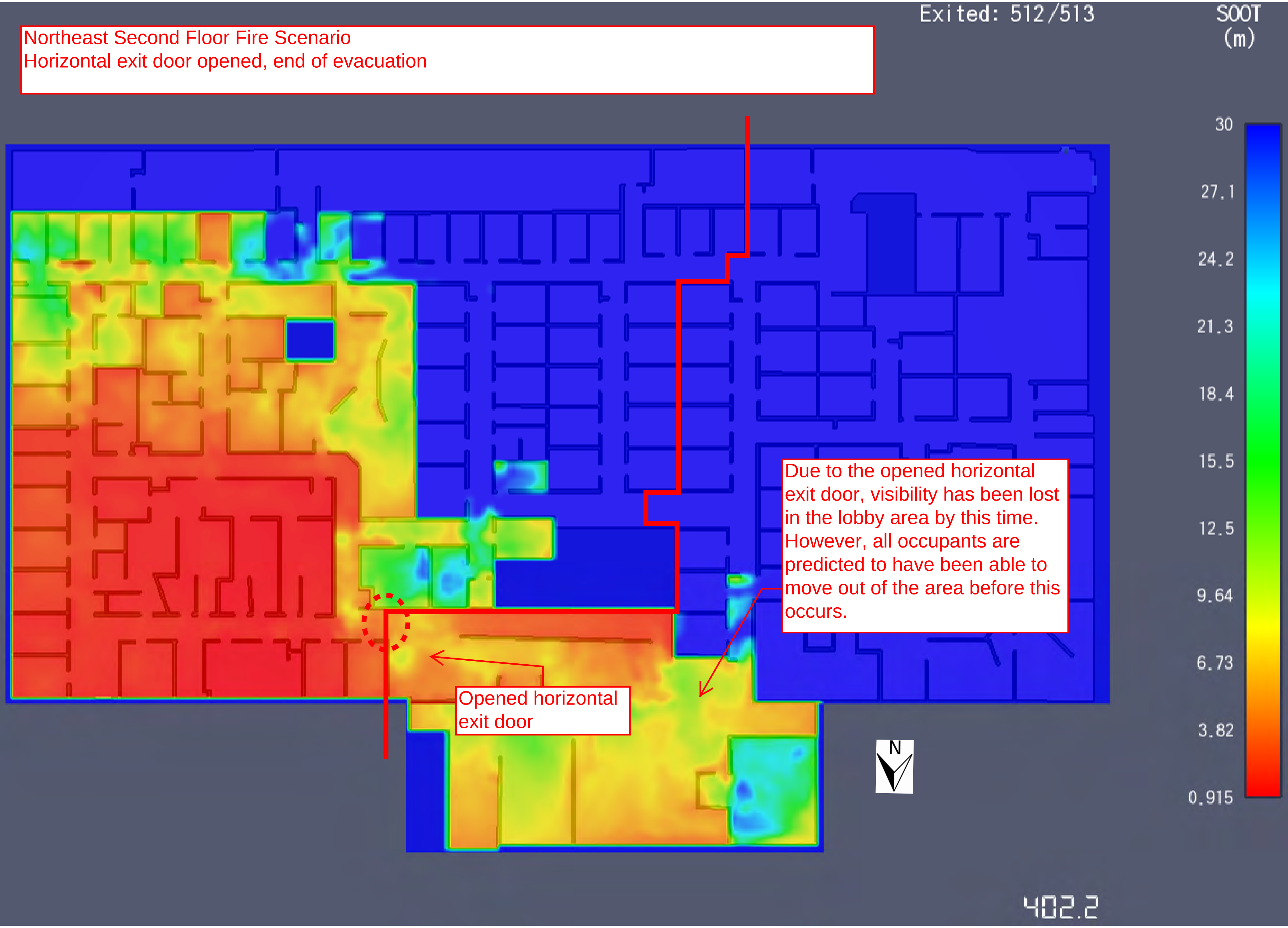

Northeast Second Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
Exited: 189/513
CARBON
(mol/mol)
0.000138
0.000124
0.00011
9.63e-005
8.25e-005
6.88e-005
5.5e-005
4.13e-005
2.75e-005
1.38e-005
0
High CO concentrations only exist in the room of origin. Even though an opened horizontal exit door is nearby, untenable conditions have not been created on the other side of the floor as a result.
Opened horizontal exit door
N
147.7

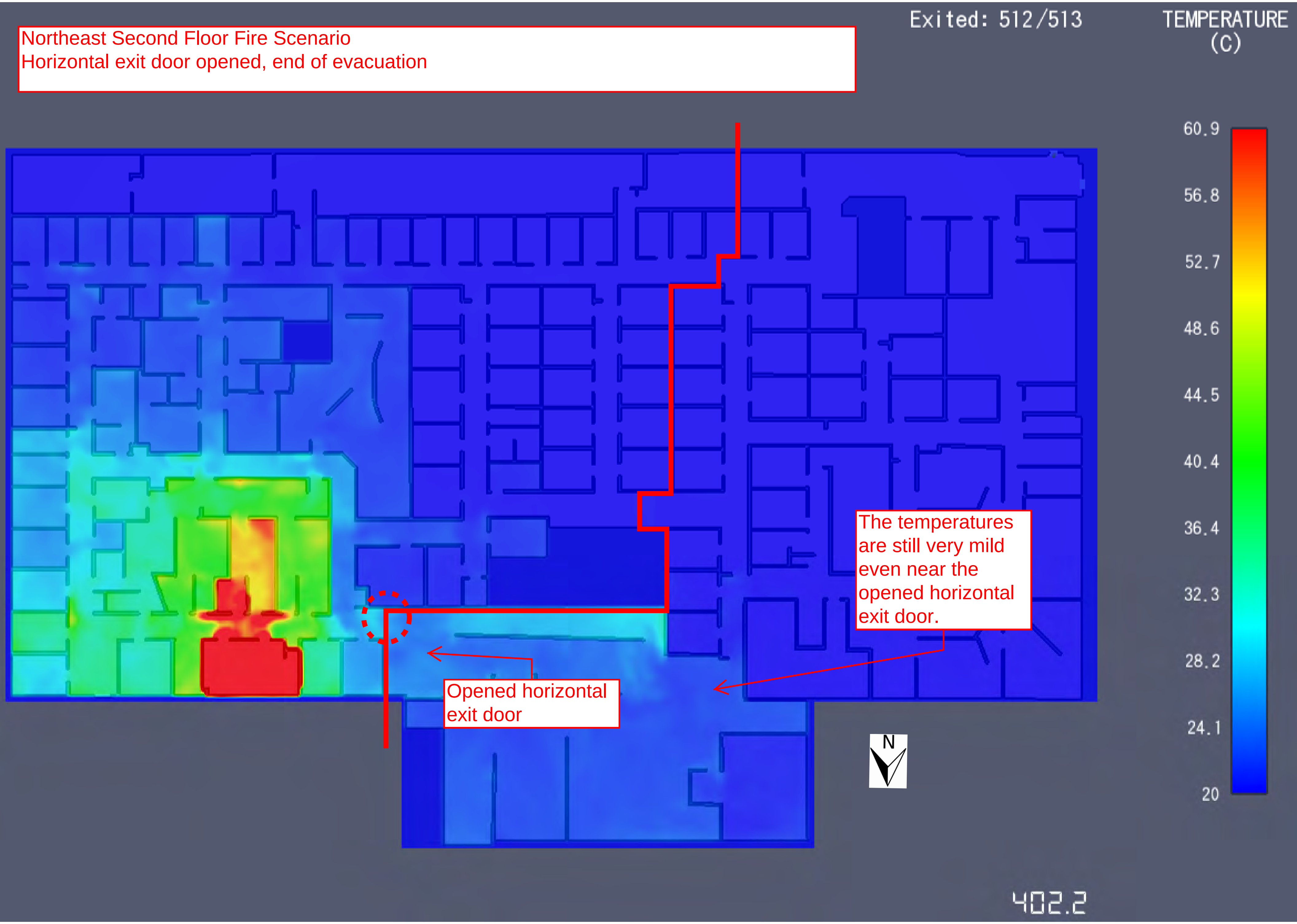

Exited: 189/513
SOOT
(m)
Northeast Second Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
30
27.1
24.2
21.3
18.4
15.5
12.5
9.64
6.73
3.82
0.915
This group of rooms has many exits from the south, east, and west sides, and all occupants should be able to evacuate the area before visibility is lost, especially with the help of the trained staff members.
Opened horizontal exit door
N
147.7


Northeast Second Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
Exited: 189/513
TEMPERATURE
(C)
60.9
56.8
52.7
48.6
44.5
40.4
36.4
32.3
28.2
24.1
20
The east side of the floor, as well as most of the west side of the floor, are tenable with regard to thermal effects.
Opened horizontal exit door
N
147.7

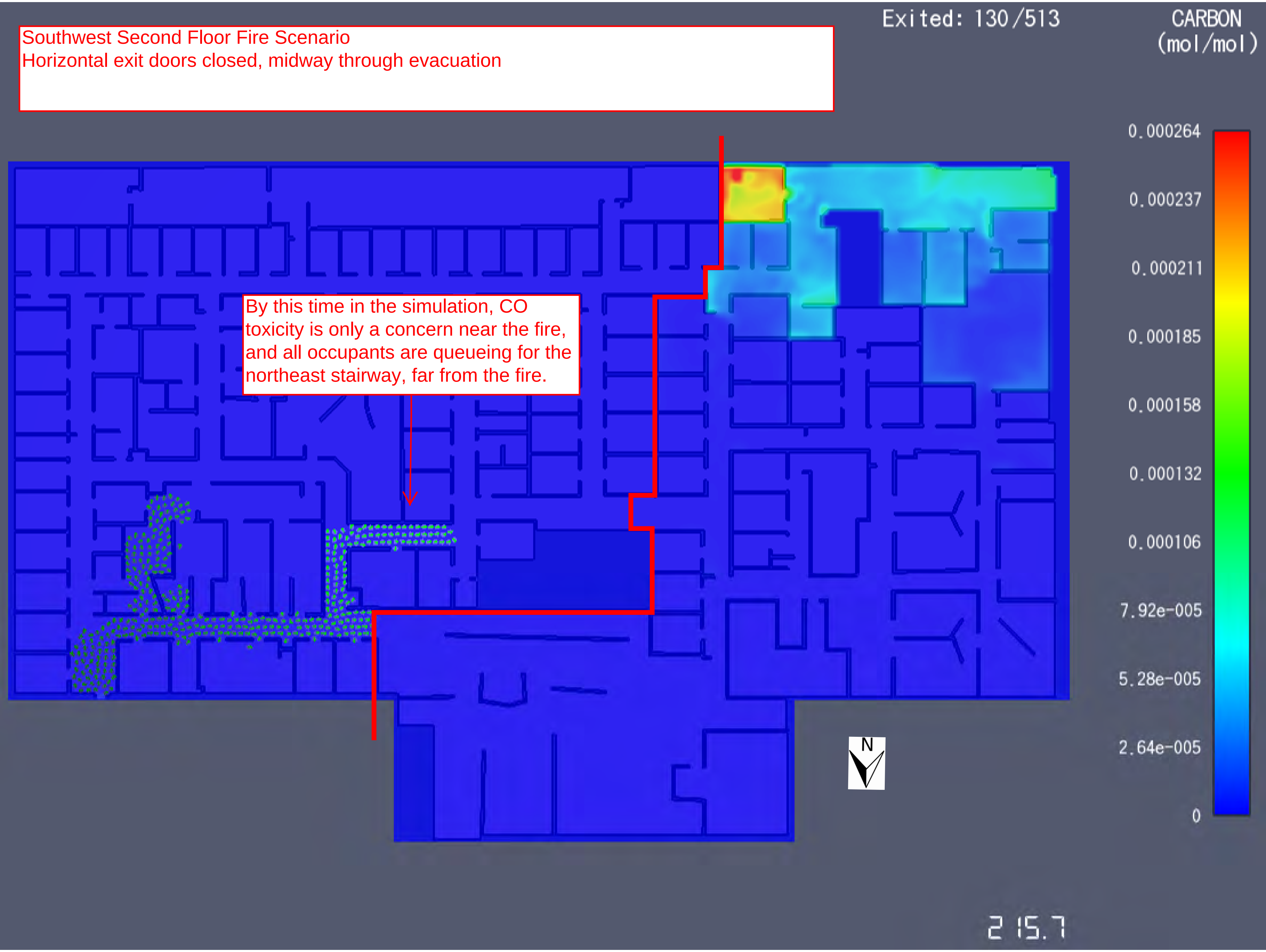


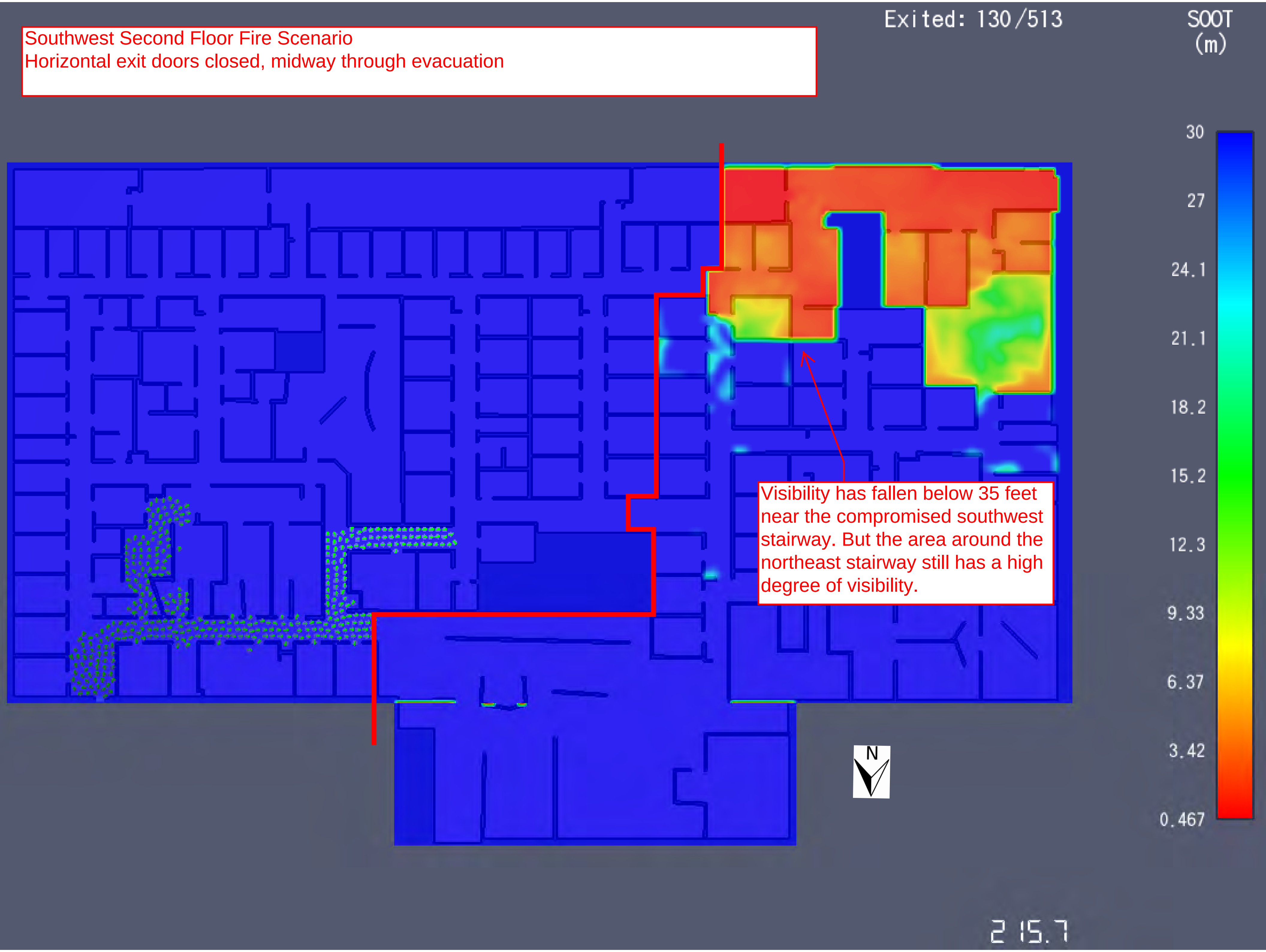
Northeast Second Floor Fire Scenario
Horizontal exit door opened, end of evacuation
Exited: 512/513
CARBON
(mol/mol)
0.000138
0.000124
0.00011
9.63e-005
8.25e-005
6.88e-005
5.5e-005
4.13e-005
2.75e-005
1.38e-005
0
The toxicity criterion, 0.0015 mol/mol (1500 ppm) of carbon monoxide, was not violated in the vicinity of the design fire
Opened horizontal exit door
Safety from the toxic effects of carbon monoxide is not guaranteed in the design fire room
N
402.2

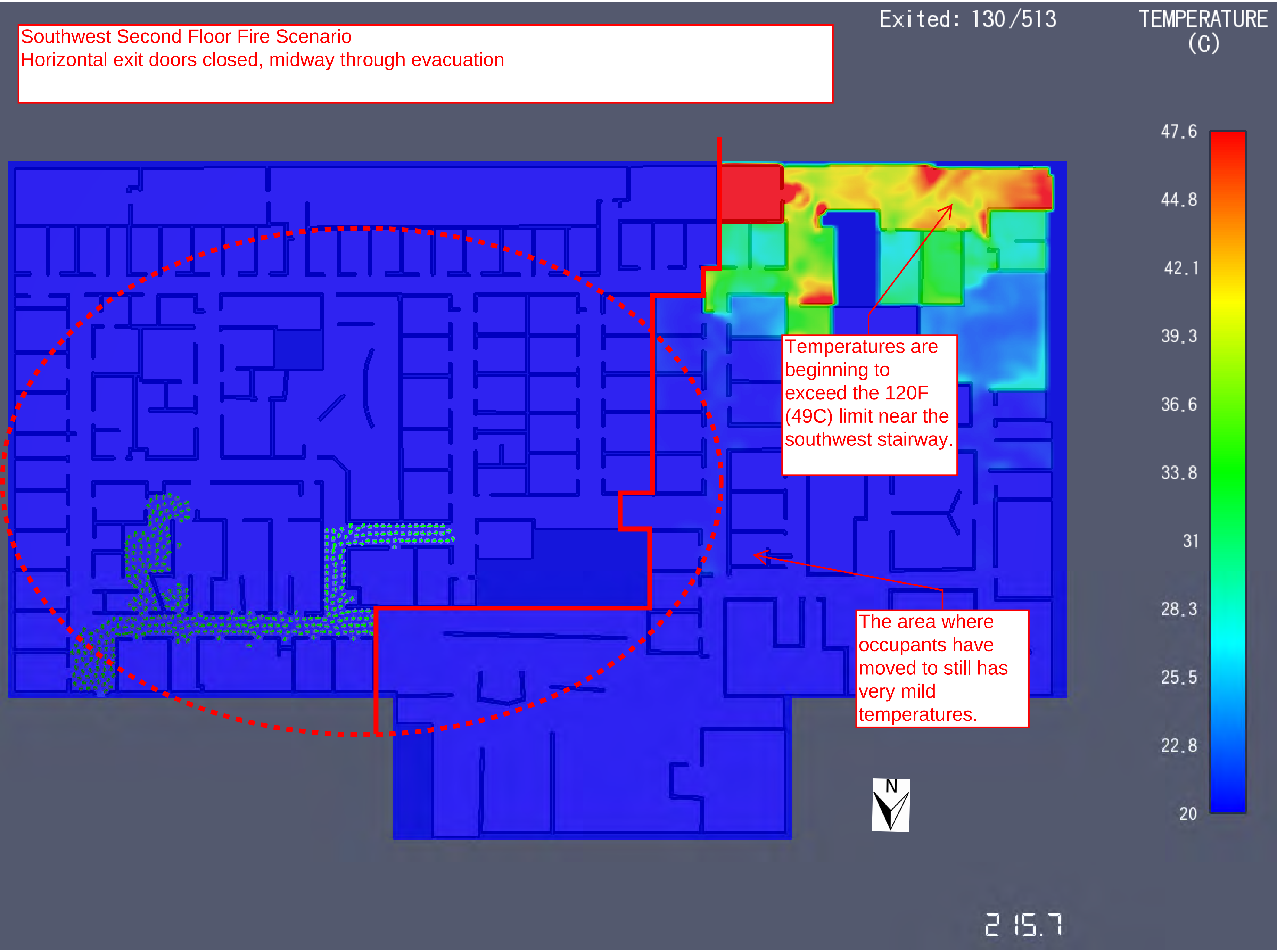

Northeast Second Floor Fire Scenario
Horizontal exit door opened, end of evacuation
Exited: 512/513
SOOT
(m)
30
27.1
24.2
21.3
18.4
15.5
12.5
9.64
6.73
3.82
0.915
Due to the opened horizontal exit door, visibility has been lost in the lobby area by this time. However, all occupants are predicted to have been able to move out of the area before this occurs.
Opened horizontal exit door
N
402.2

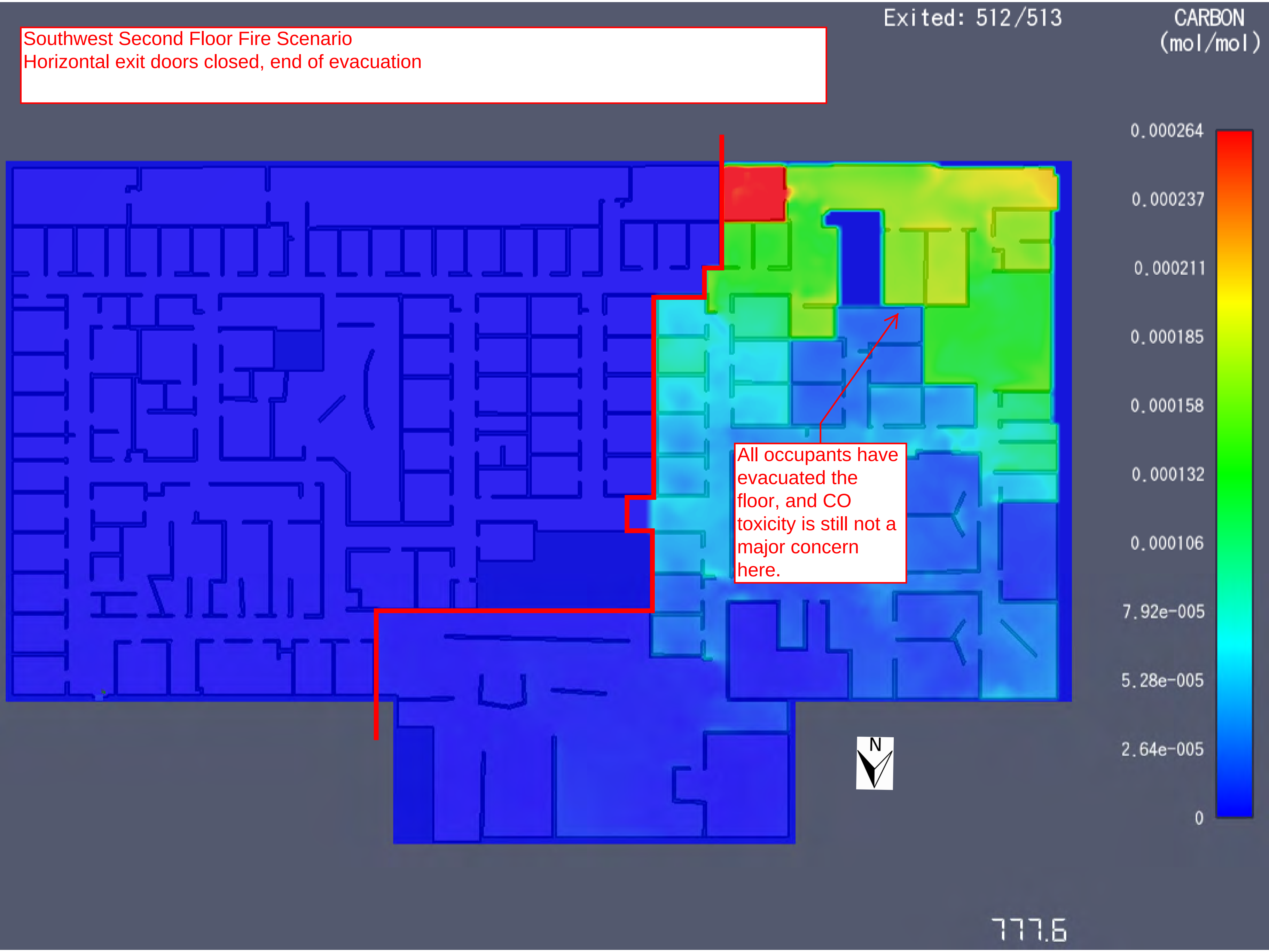


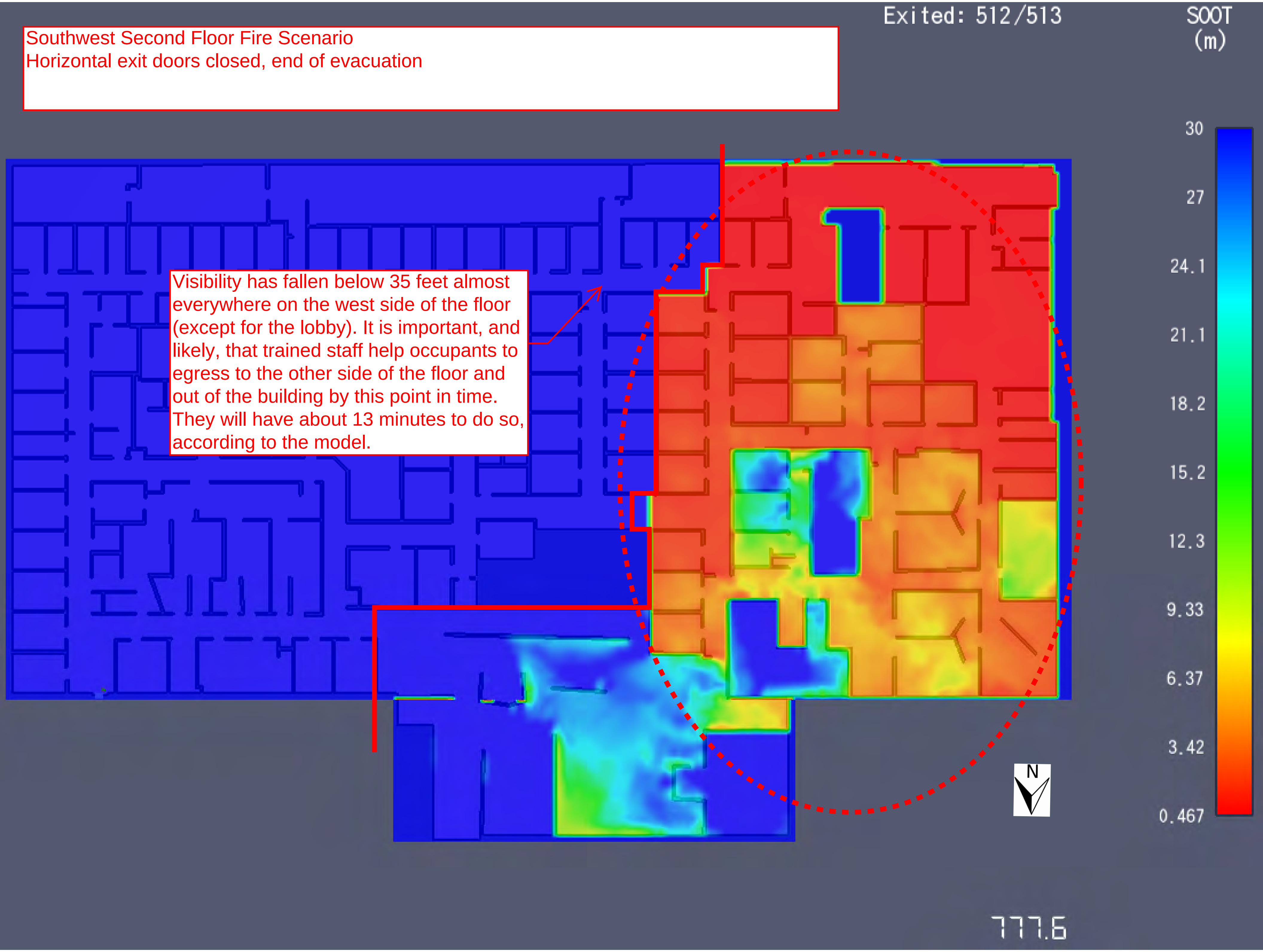
Northeast Second Floor Fire Scenario
Horizontal exit door opened, end of evacuation
Exited: 512/513
TEMPERATURE (C)
60.9
56.8
52.7
48.6
44.5
40.4
36.4
32.3
28.2
24.1
20
The temperatures are still very mild even near the opened horizontal exit door.
Opened horizontal exit door
N
402.2

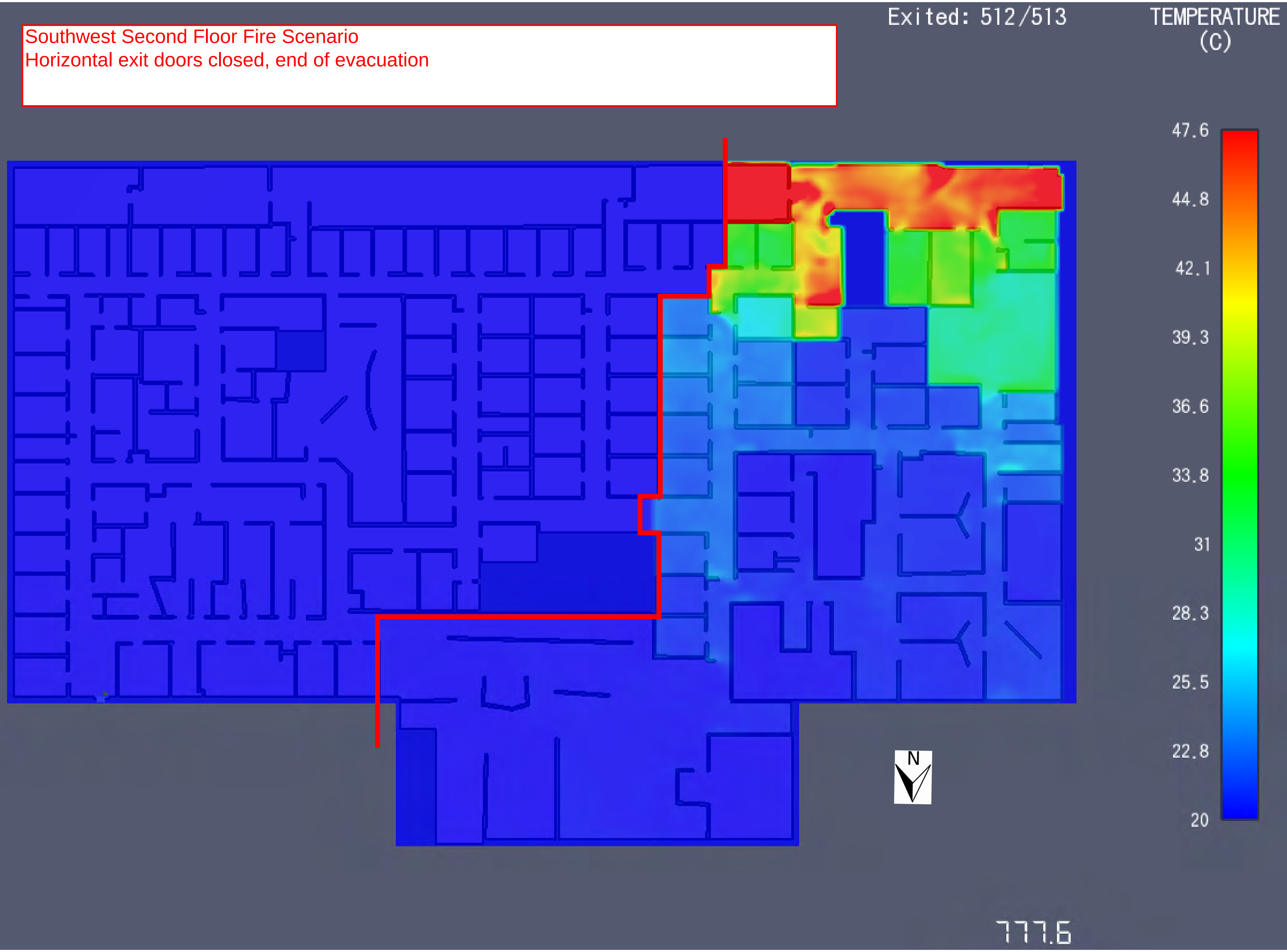

Southwest Second Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 130/513
CARBON
(mol/mol)
0.000264
0.000237
0.000211
0.000185
0.000158
0.000132
0.000106
7.92e-005
5.28e-005
2.64e-005
0
By this time in the simulation, CO toxicity is only a concern near the fire, and all occupants are queueing for the northeast stairway, far from the fire.
N
215.7

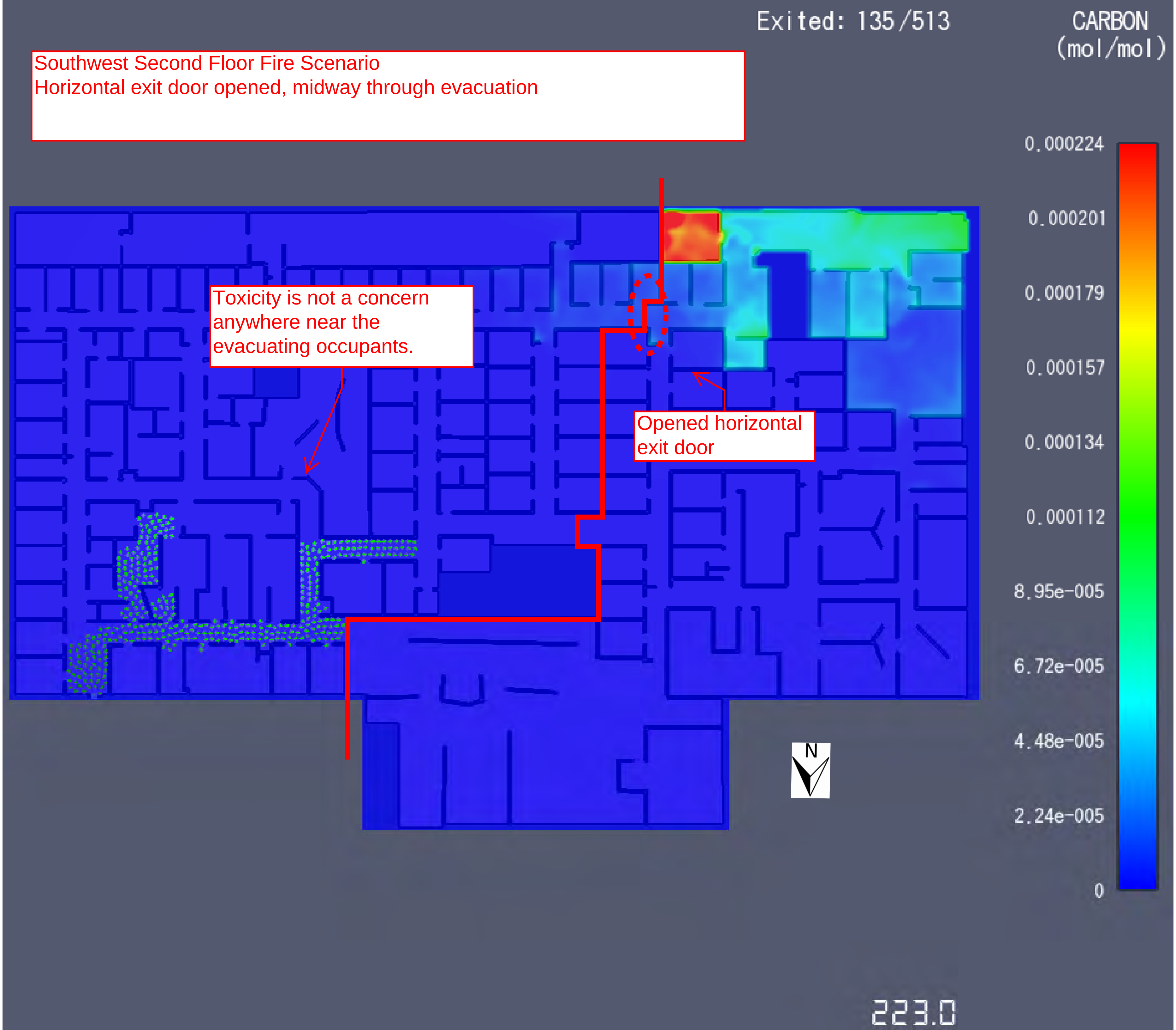

Southwest Second Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 130/513
SOOT
(m)
30
27
24.1
21.1
18.2
15.2
12.3
9.33
6.37
3.42
0.467
Visibility has fallen below 35 feet near the compromised southwest stairway. But the area around the northeast stairway still has a high degree of visibility.
N
215.7


Southwest Second Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
Exited: 130/513
TEMPERATURE (C)
47.6
44.8
42.1
39.3
36.6
33.8
31
28.3
25.5
22.8
20
Temperatures are beginning to exceed the 120F (49C) limit near the southwest stairway.
The area where occupants have moved to still has very mild temperatures.
N
215.7

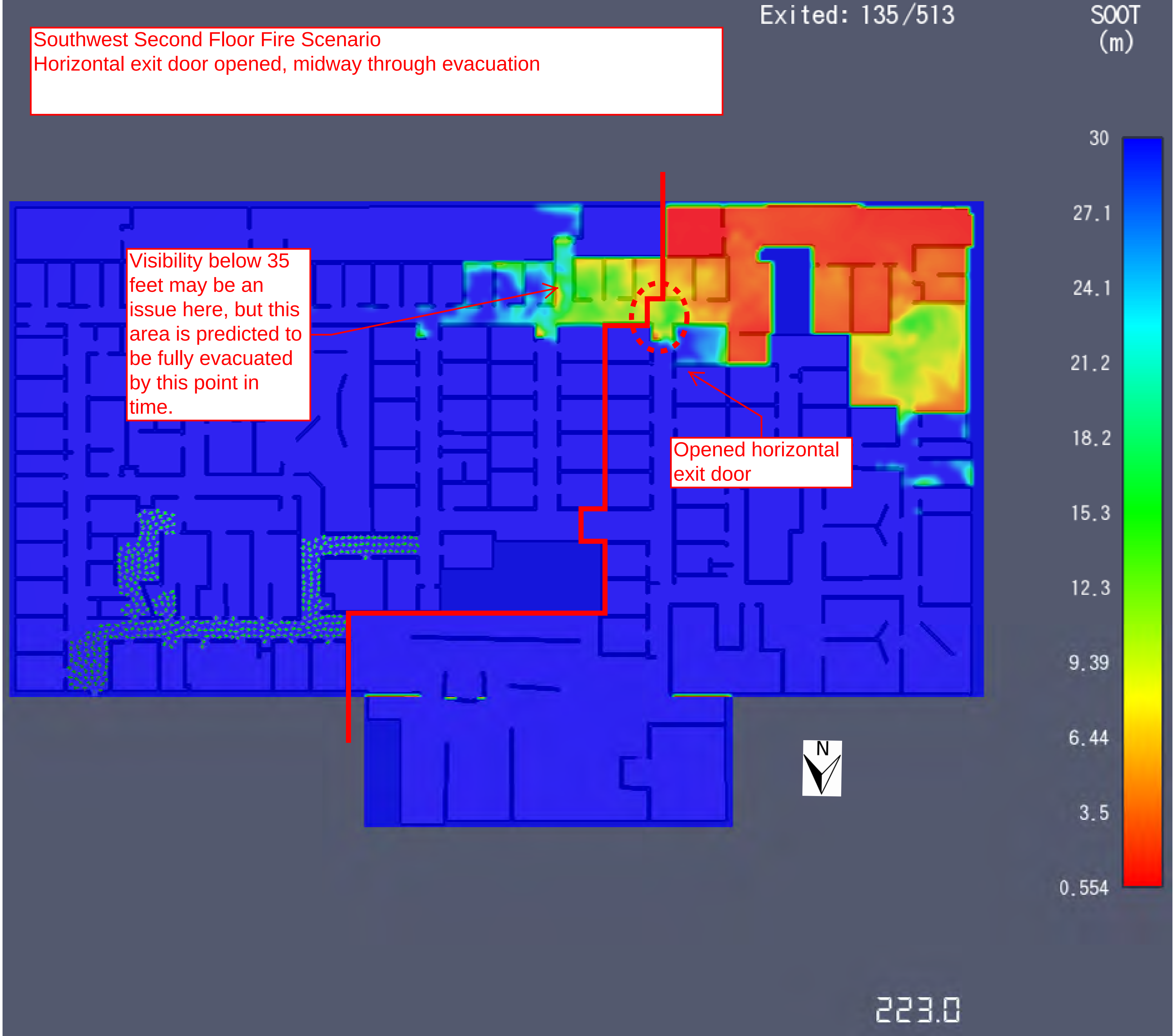

Southwest Second Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
Exited: 512/513
CARBON
(mol/mol)
0.000264
0.000237
0.000211
0.000185
0.000158
0.000132
0.000106
7.92e-005
5.28e-005
2.64e-005
0
All occupants have evacuated the floor, and CO toxicity is still not a major concern here.
N
777.6


Southwest Second Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
Exited: 512/513
SOOT
(m)
30
27
24.1
21.1
18.2
15.2
12.3
9.33
6.37
3.42
0.467
Visibility has fallen below 35 feet almost everywhere on the west side of the floor (except for the lobby). It is important, and likely, that trained staff help occupants to egress to the other side of the floor and out of the building by this point in time. They will have about 13 minutes to do so, according to the model.
N
777.6

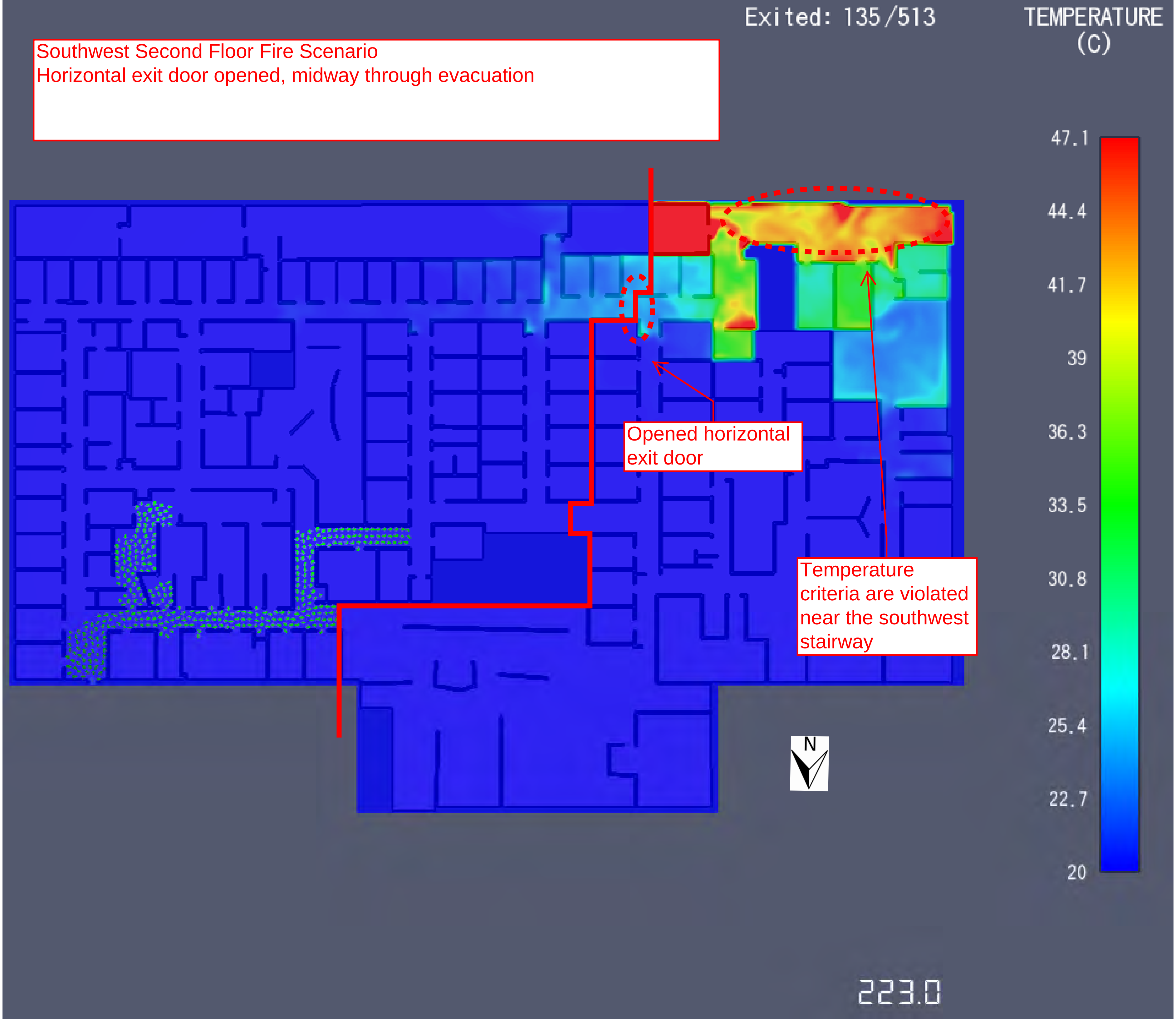

Southwest Second Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
Exited: 512/513
TEMPERATURE
(C)
47.6
44.8
42.1
39.3
36.6
33.8
31
28.3
25.5
22.8
20
N
777.6

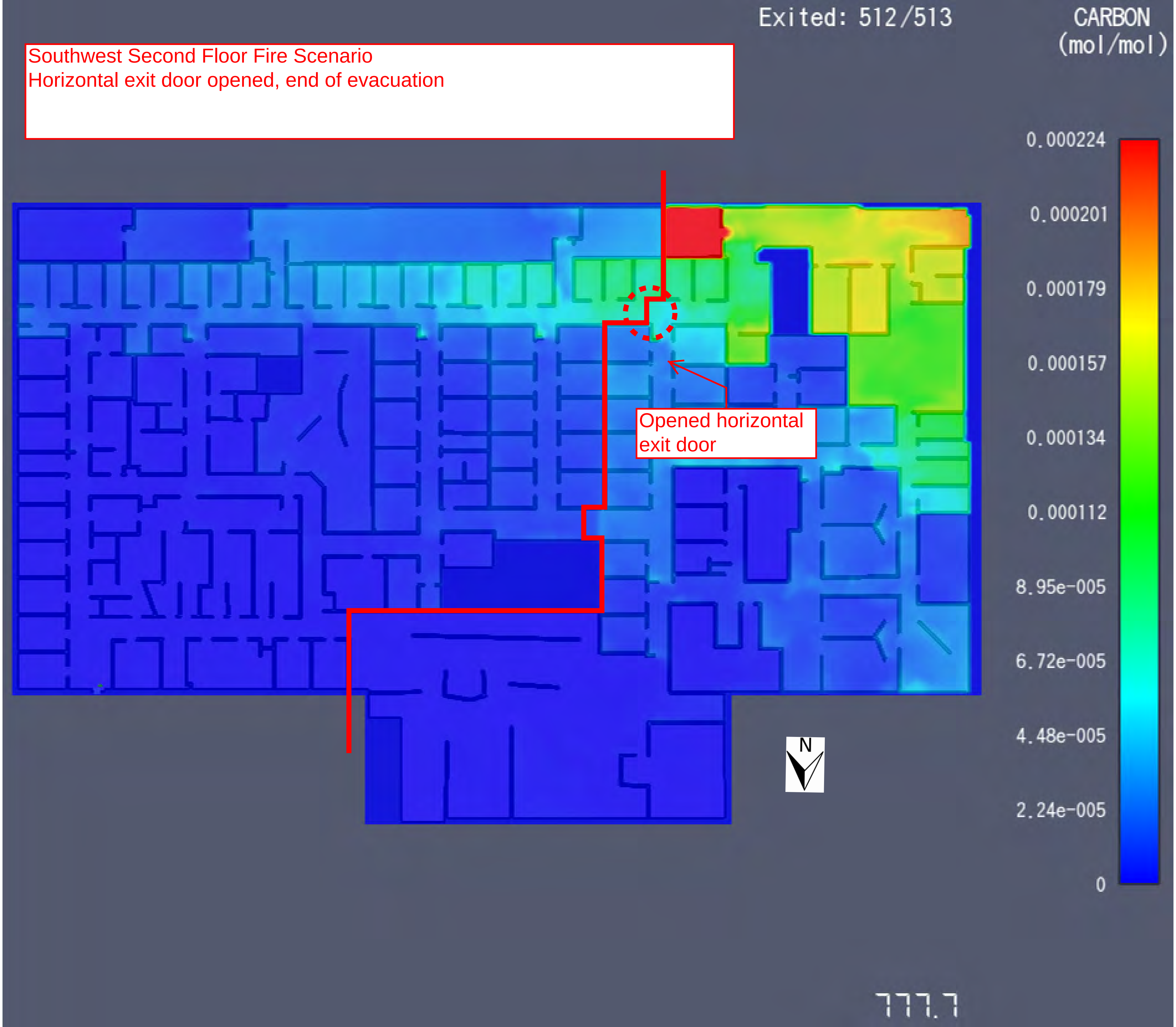


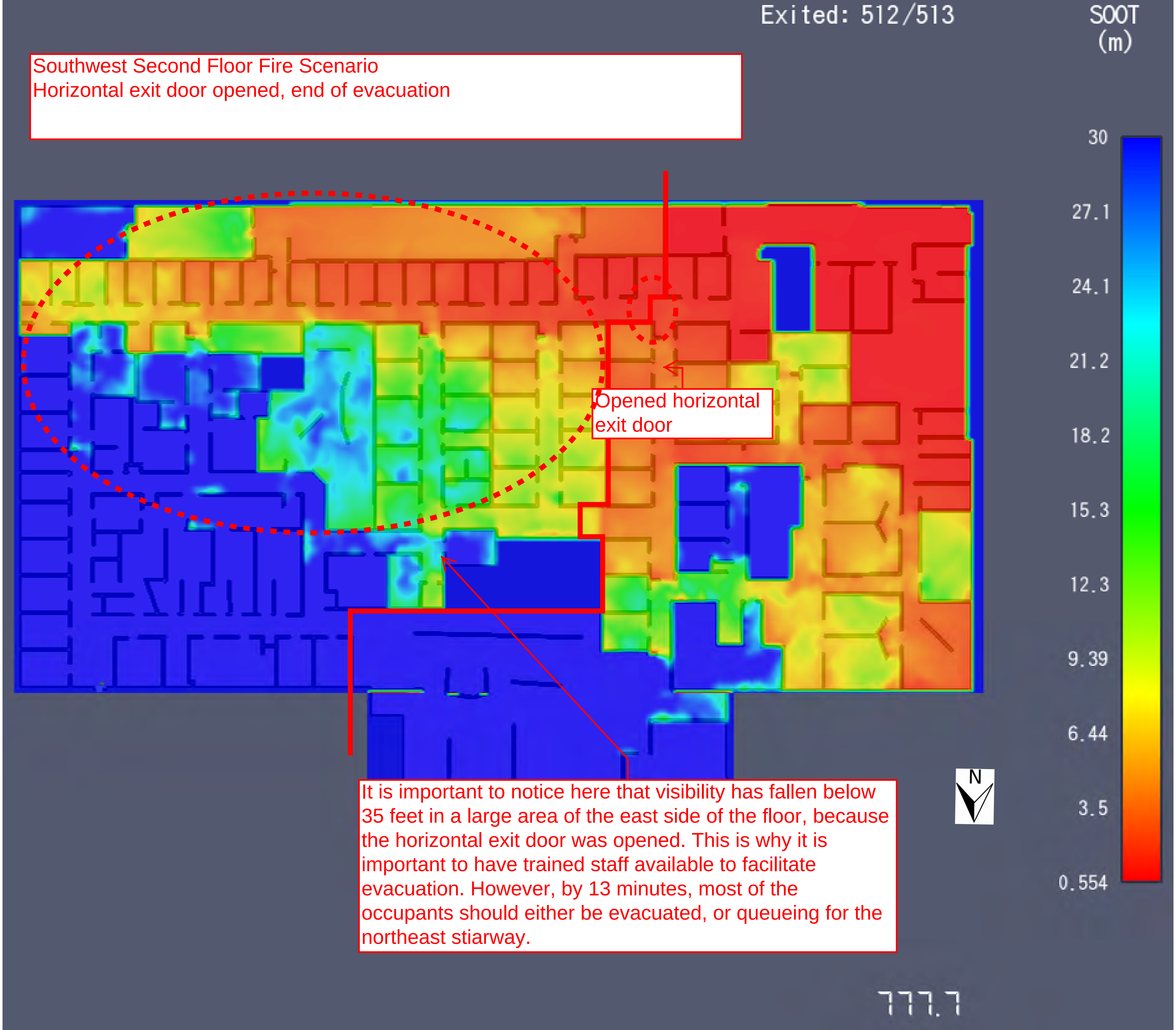
Exited: 135/513
CARBON
(mol/mol)
Southwest Second Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
Toxicity is not a concern anywhere near the evacuating occupants.
Opened horizontal exit door
0.000224
0.000201
0.000179
0.000157
0.000134
0.000112
8.95e-005
6.72e-005
4.48e-005
2.24e-005
0
N
223.0



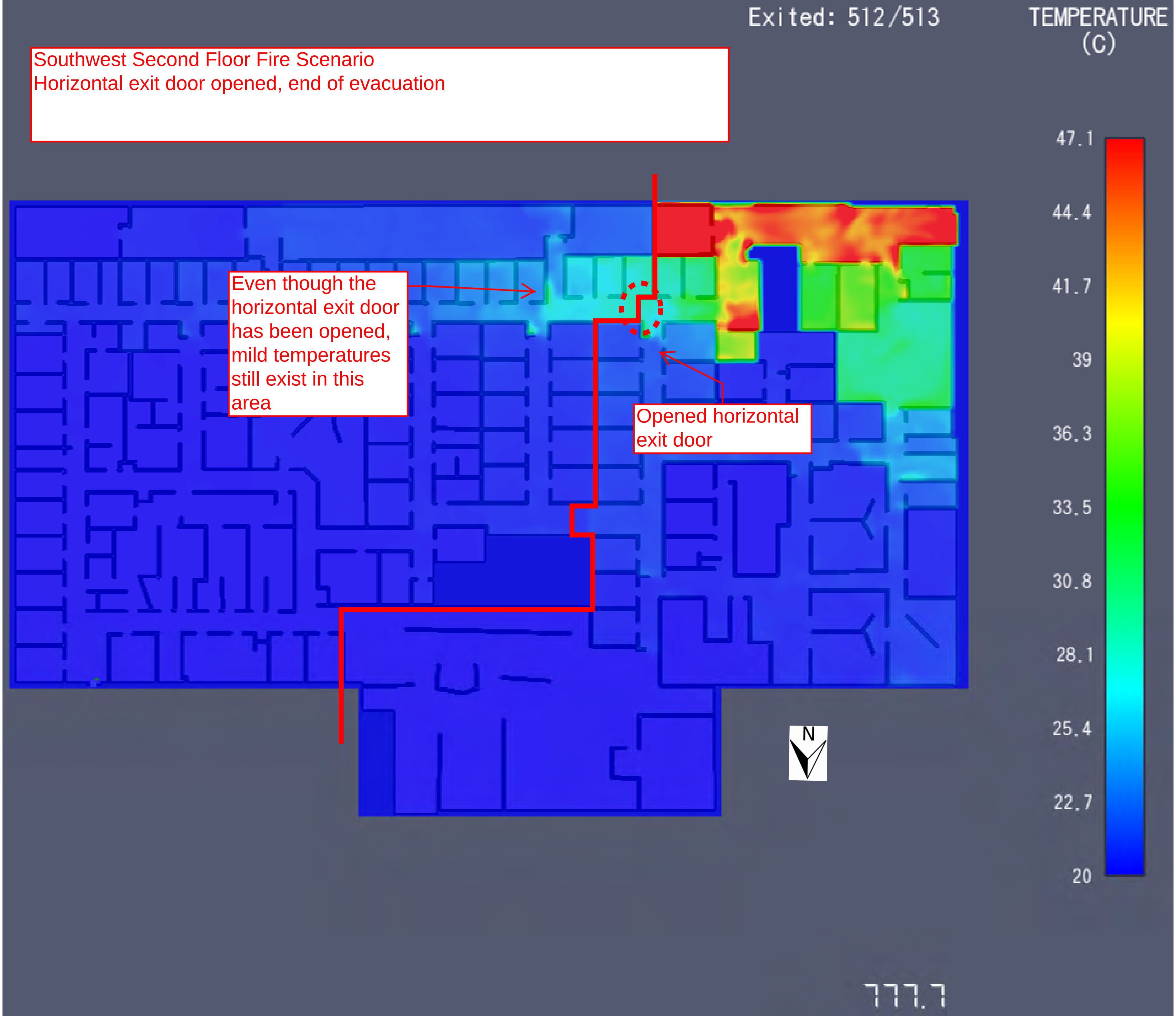
Southwest Second Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
Exited: 135/513
SOOT
(m)
30
27.1
24.1
21.2
18.2
15.3
12.3
9.39
6.44
3.5
0.554
Visibility below 35 feet may be an issue here, but this area is predicted to be fully evacuated by this point in time.
Opened horizontal exit door
N
223.0


Exited: 135/513
TEMPERATURE (C)
Southwest Second Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
47.1
44.4
41.7
39
36.3
33.5
30.8
28.1
25.4
22.7
20
Opened horizontal exit door
Temperature criteria are violated near the southwest stairway
N
223.0

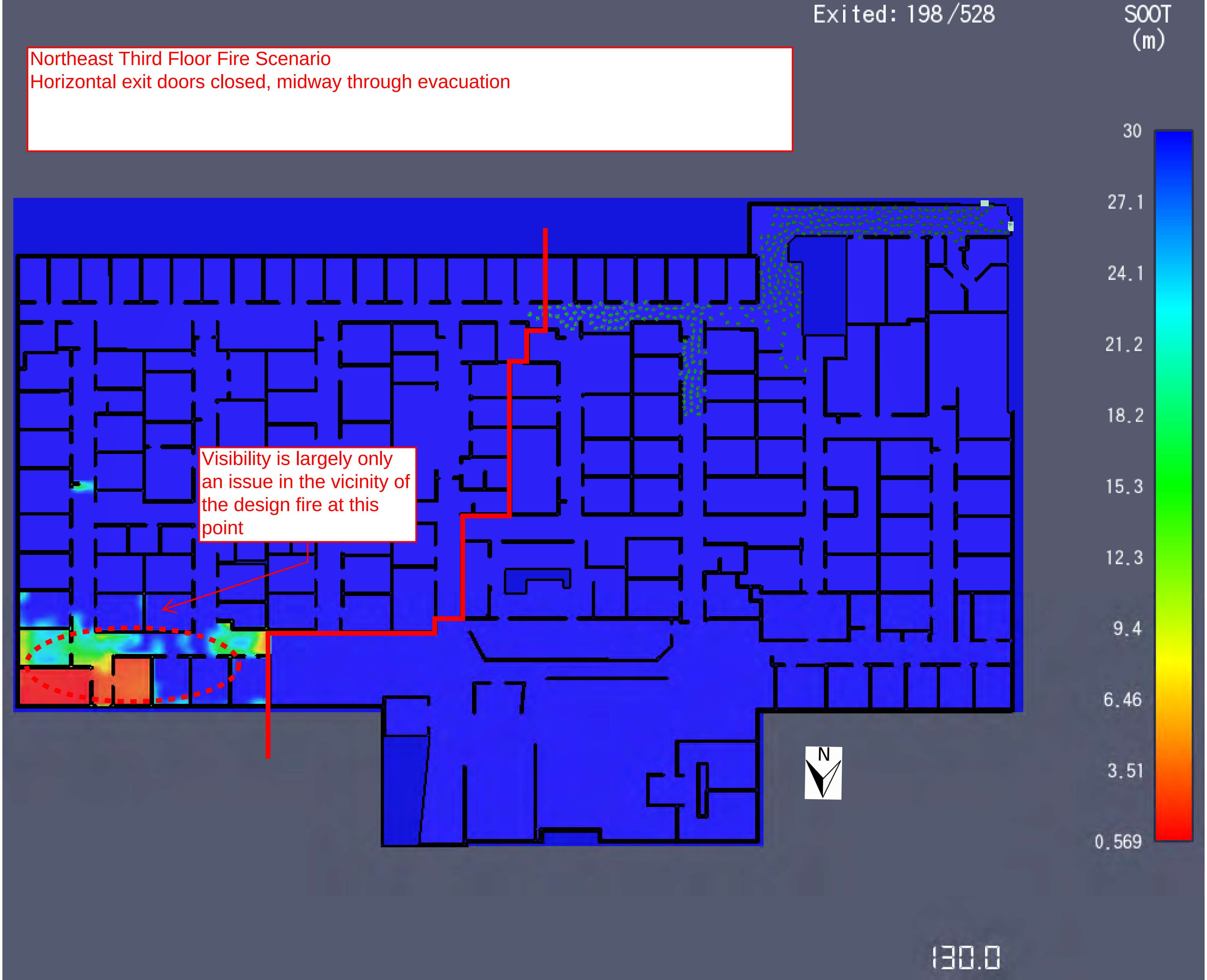

Exited: 512/513
CARBON
(mol/mol)
Southwest Second Floor Fire Scenario
Horizontal exit door opened, end of evacuation
0.000224
0.000201
0.000179
0.000157
0.000134
0.000112
8.95e-005
6.72e-005
4.48e-005
2.24e-005
0
Opened horizontal exit door
N
777.7



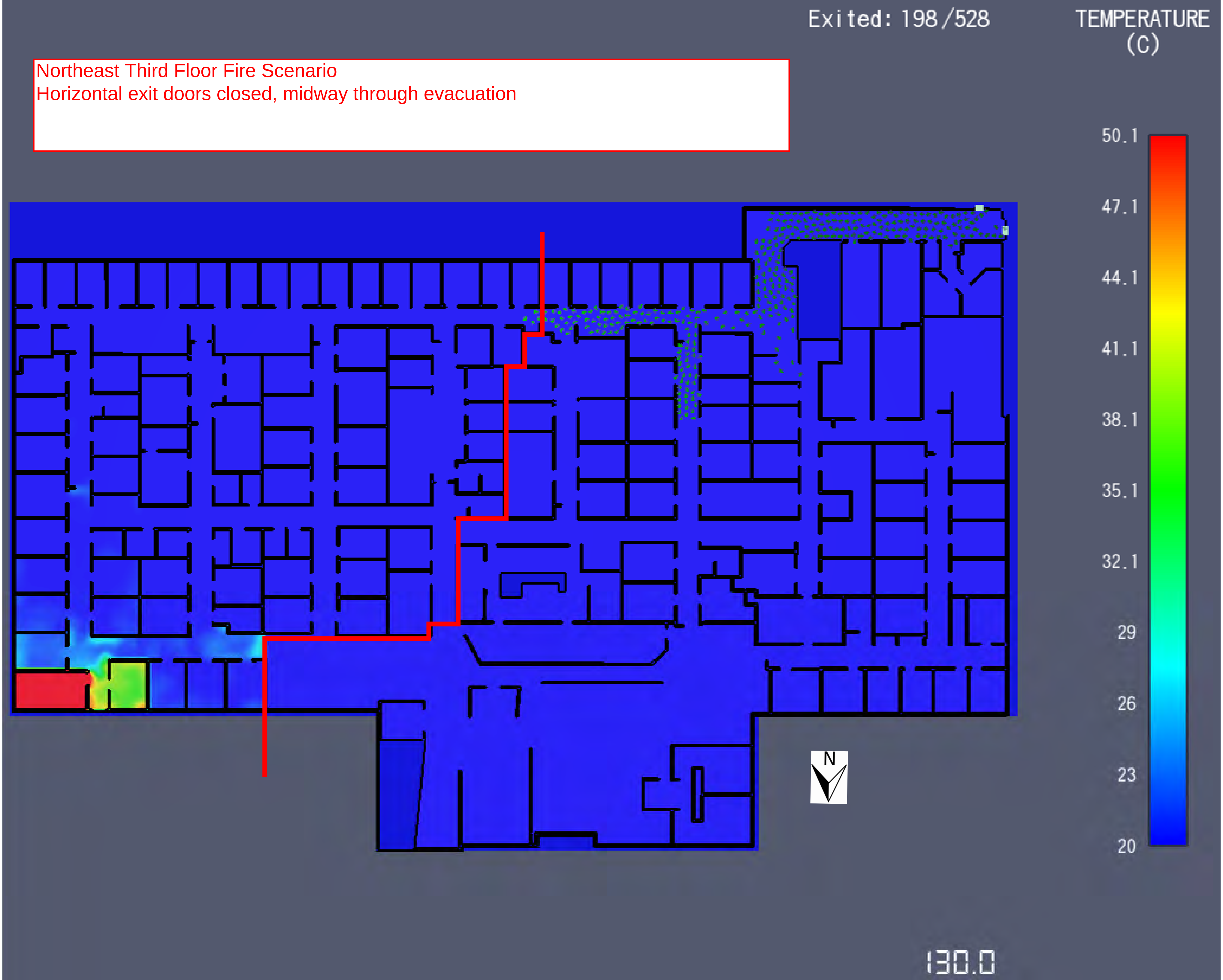
Exited: 512/513
SOOT
(m)
Southwest Second Floor Fire Scenario
Horizontal exit door opened, end of evacuation
30
27.1
24.1
21.2
18.2
15.3
12.3
9.39
6.44
3.5
0.554
Opened horizontal exit door
N
It is important to notice here that visibility has fallen below 35 feet in a large area of the east side of the floor, because the horizontal exit door was opened. This is why it is important to have trained staff available to facilitate evacuation. However, by 13 minutes, most of the occupants should either be evacuated, or queueing for the northeast stiarway.
777.7


Exited: 512/513
TEMPERATURE (C)
Southwest Second Floor Fire Scenario
Horizontal exit door opened, end of evacuation
47.1
44.4
41.7
39
36.3
33.5
30.8
28.1
25.4
22.7
20
Even though the horizontal exit door has been opened, mild temperatures still exist in this area
Opened horizontal exit door
N
777.7

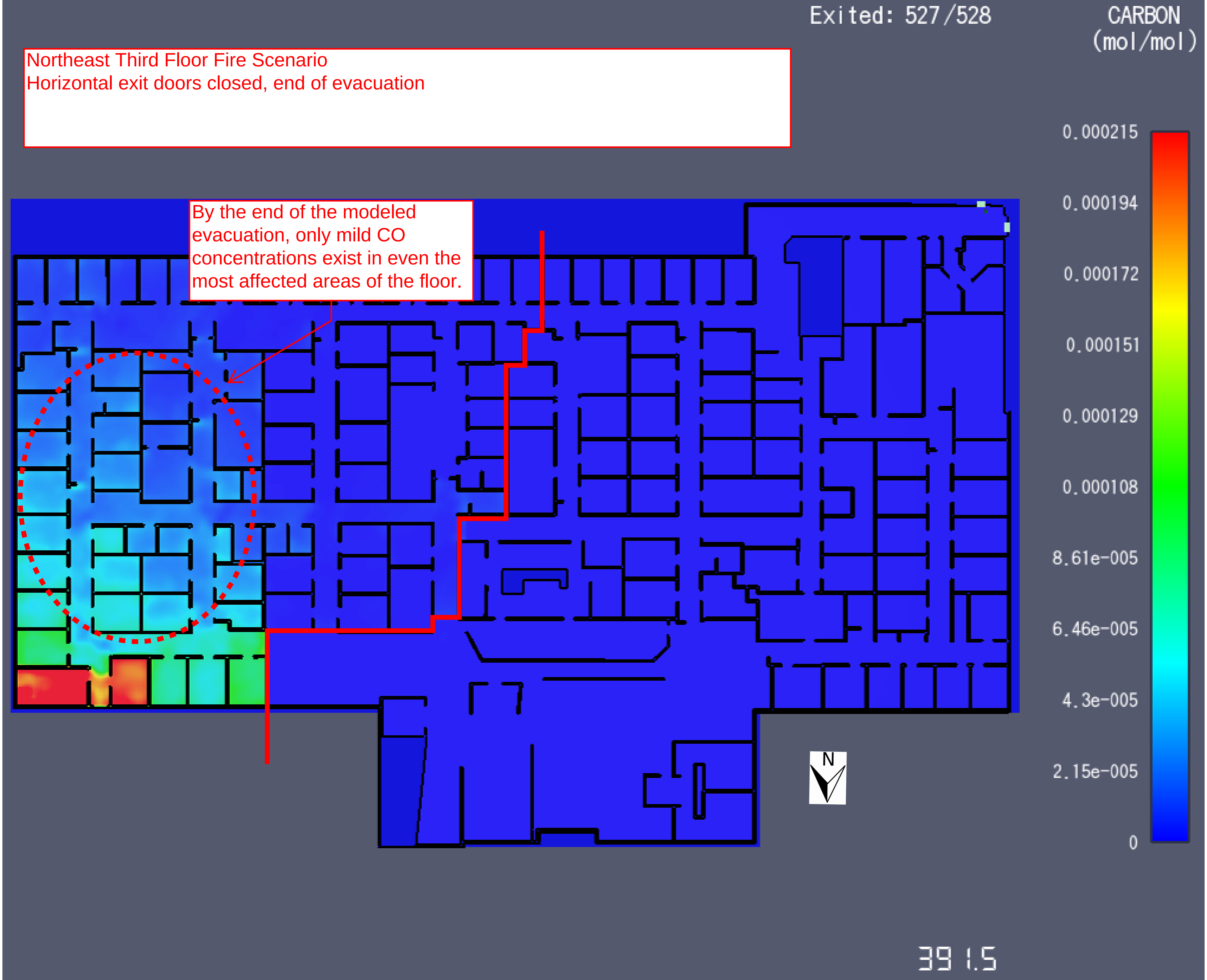

Exited: 198/528
CARBON (mol/mol)
Northeast Third Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
0.000215
0.000194
0.000172
0.000151
0.000129
0.000108
8.61e-005
6.46e-005
4.3e-005
2.15e-005
0
CO toxicity is only a concern in this area
N
130.0



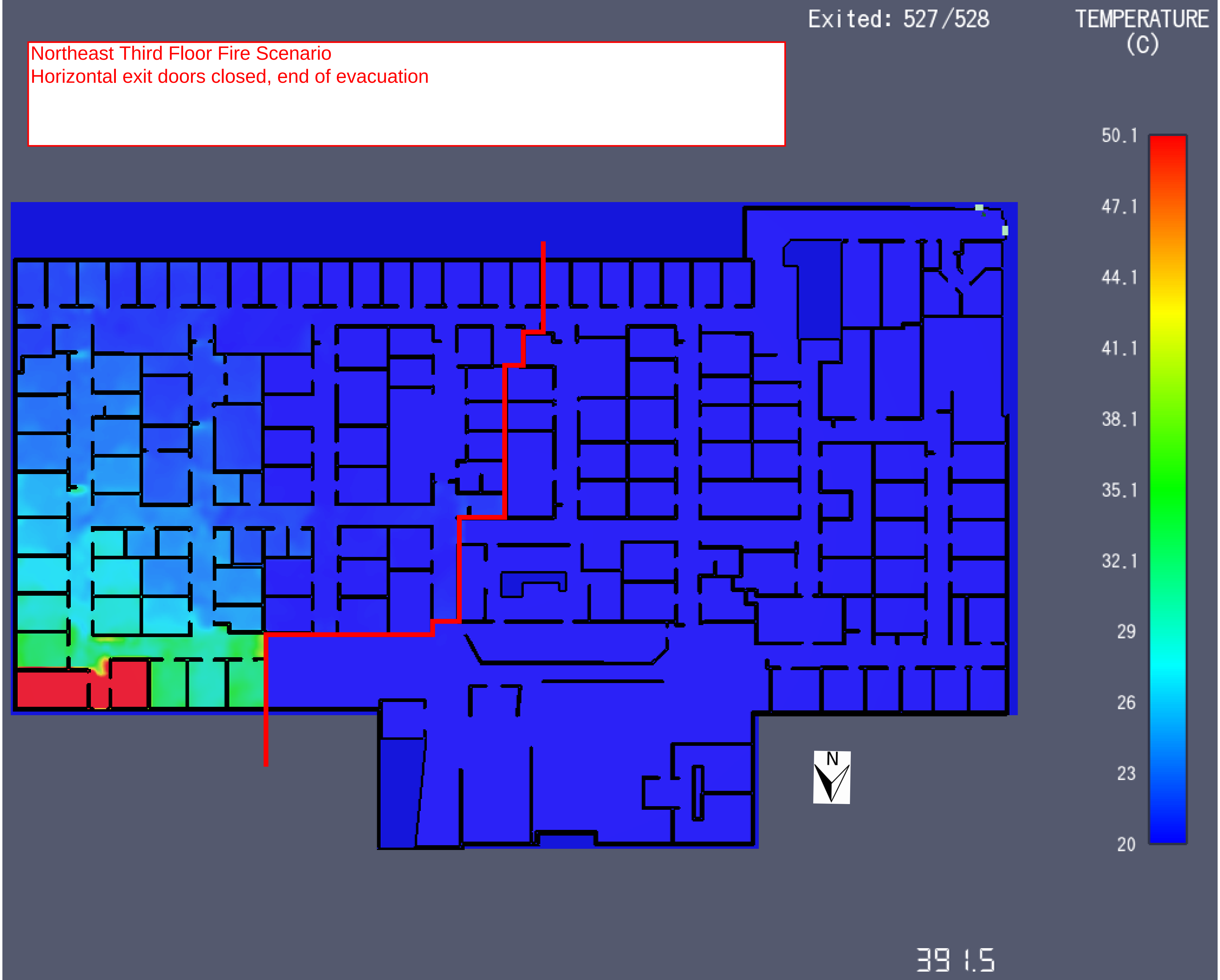
Exited: 198 /528
SOOT
(m)
Northeast Third Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
Visibility is largely only an issue in the vicinity of the design fire at this point
30
27.1
24.1
21.2
18.2
15.3
12.3
9.4
6.46
3.51
0.569
N
130.0



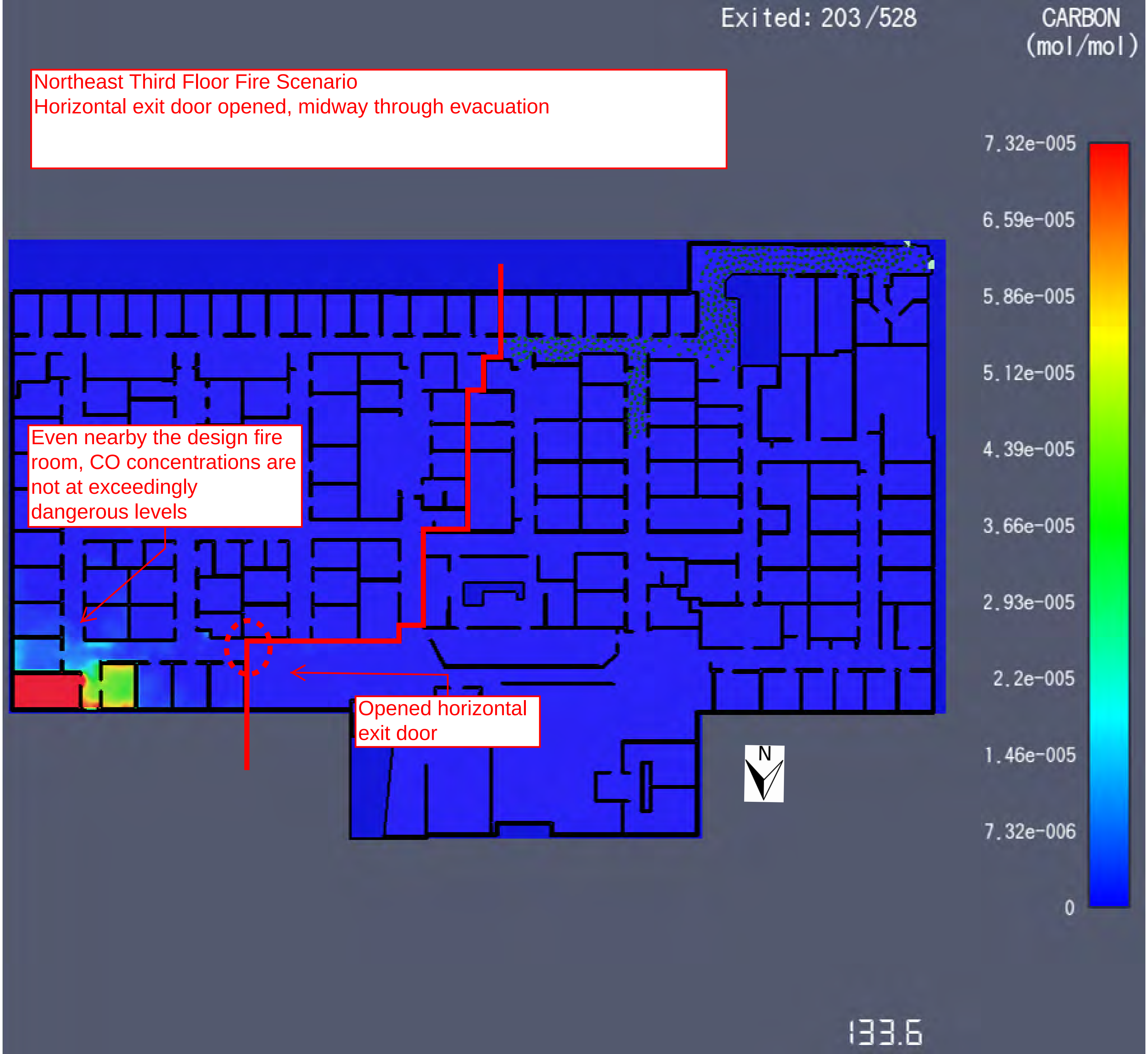
Exited: 198 /528
TEMPERATURE (C)
Northeast Third Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
50.1
47.1
44.1
41.1
38.1
35.1
32.1
29
26
23
20
N
130.0


Exited: 527/528
CARBON (mol/mol)
Northeast Third Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
By the end of the modeled evacuation, only mild CO concentrations exist in even the most affected areas of the floor.
0.000215
0.000194
0.000172
0.000151
0.000129
0.000108
8.61e-005
6.46e-005
4.3e-005
2.15e-005
0
N
391.5

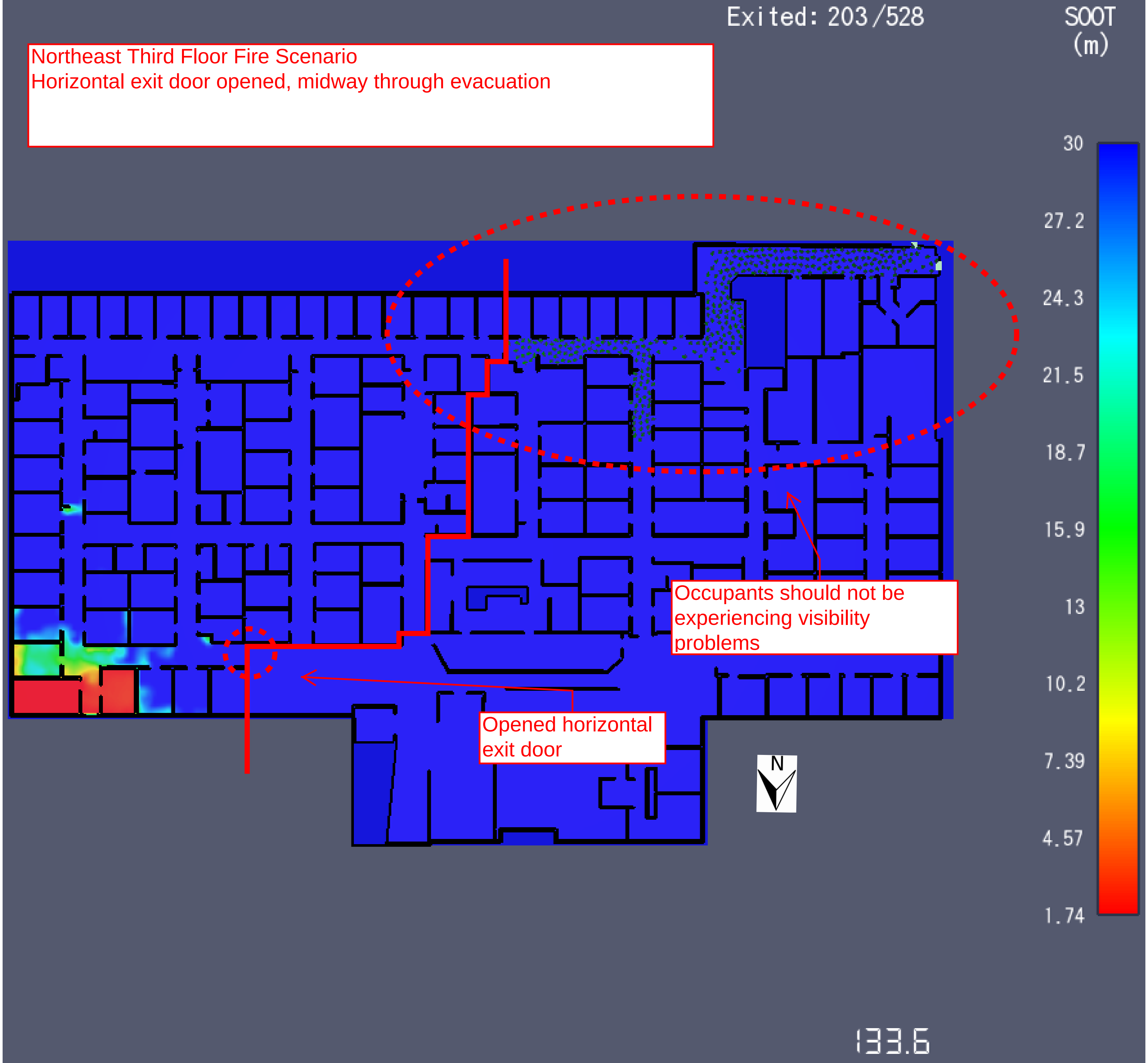

Exited: 527/528
SOOT
(m)
30
27.1
24.1
21.2
18.2
15.3
12.3
9.4
6.46
3.51
0.569
Northeast Third Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
Visibility has been lost in this portion of the floor, but the west 75% of the floor still has enough visibility for evacuation. Also, by this time, the model predicts that the floor can be fully evacuated.
N
391.5

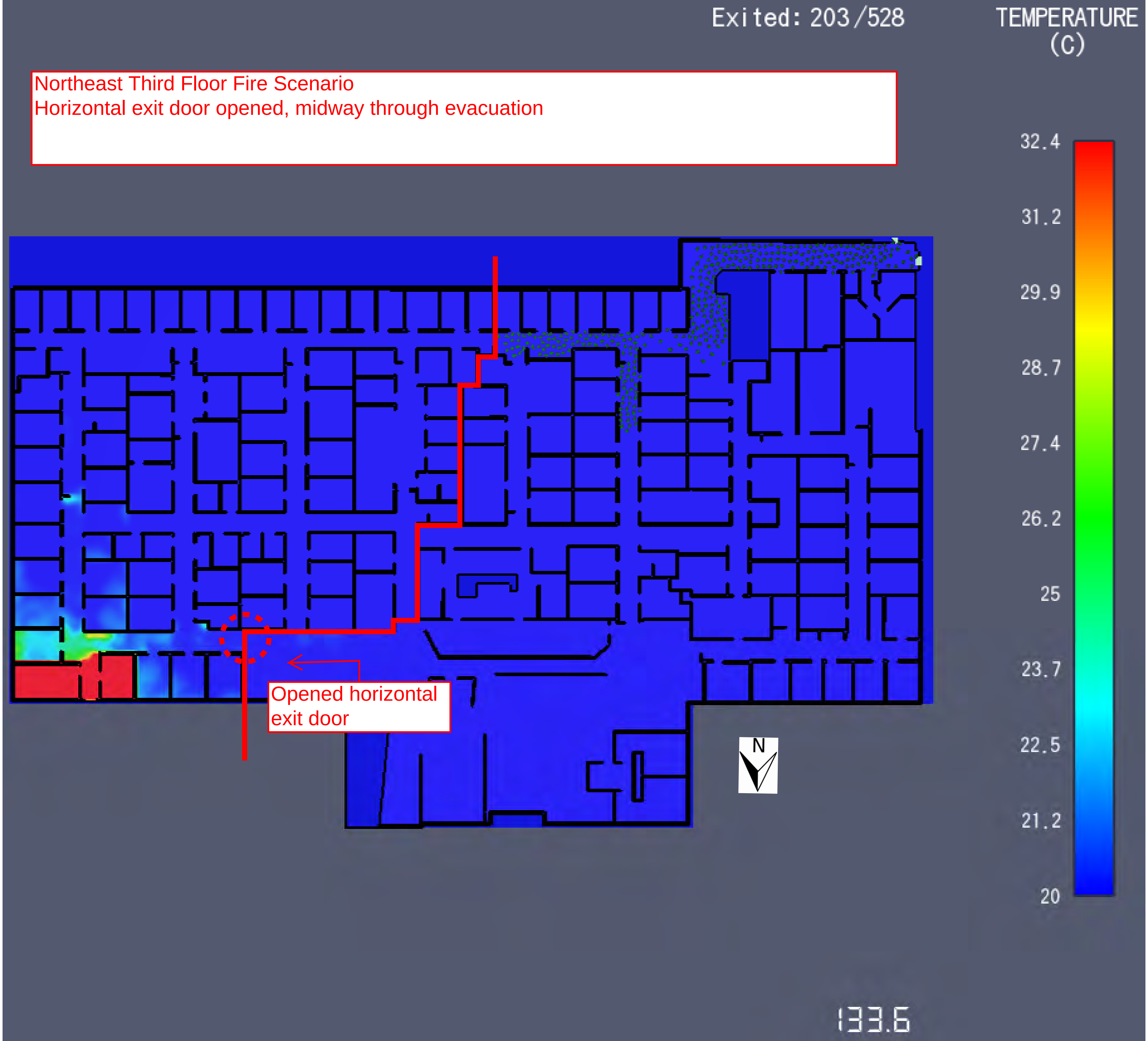


Exited: 527/528
TEMPERATURE (C)
Northeast Third Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
50.1
47.1
44.1
41.1
38.1
35.1
32.1
29
26
23
20
N
391.5

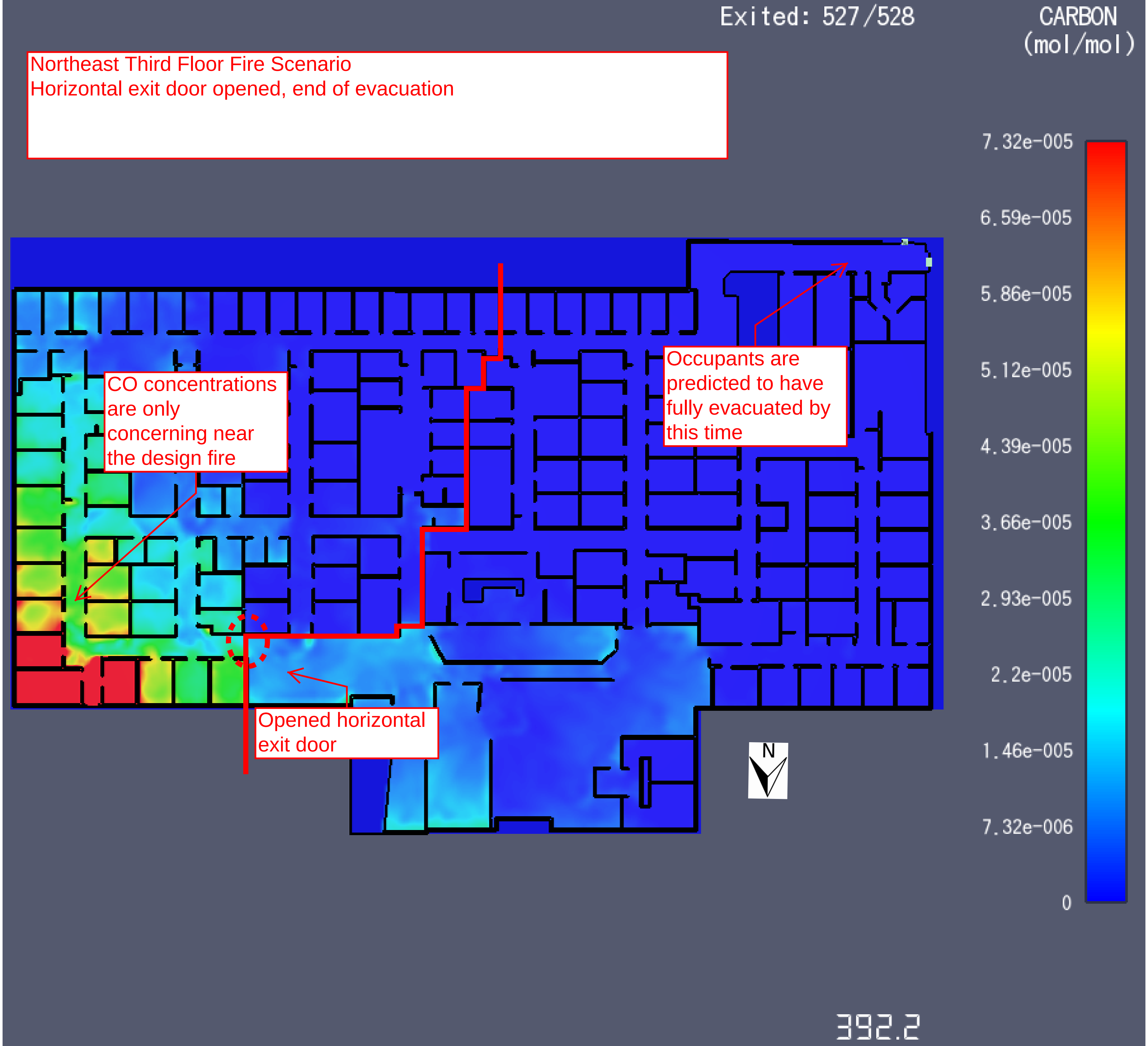


Exited: 203/528
CARBON
(mol/mol)
Northeast Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
7.32e-005
6.59e-005
5.86e-005
5.12e-005
4.39e-005
3.66e-005
2.93e-005
2.2e-005
1.46e-005
7.32e-006
0
Even nearby the design fire room, CO concentrations are not at exceedingly dangerous levels
Opened horizontal exit door
N
133.6

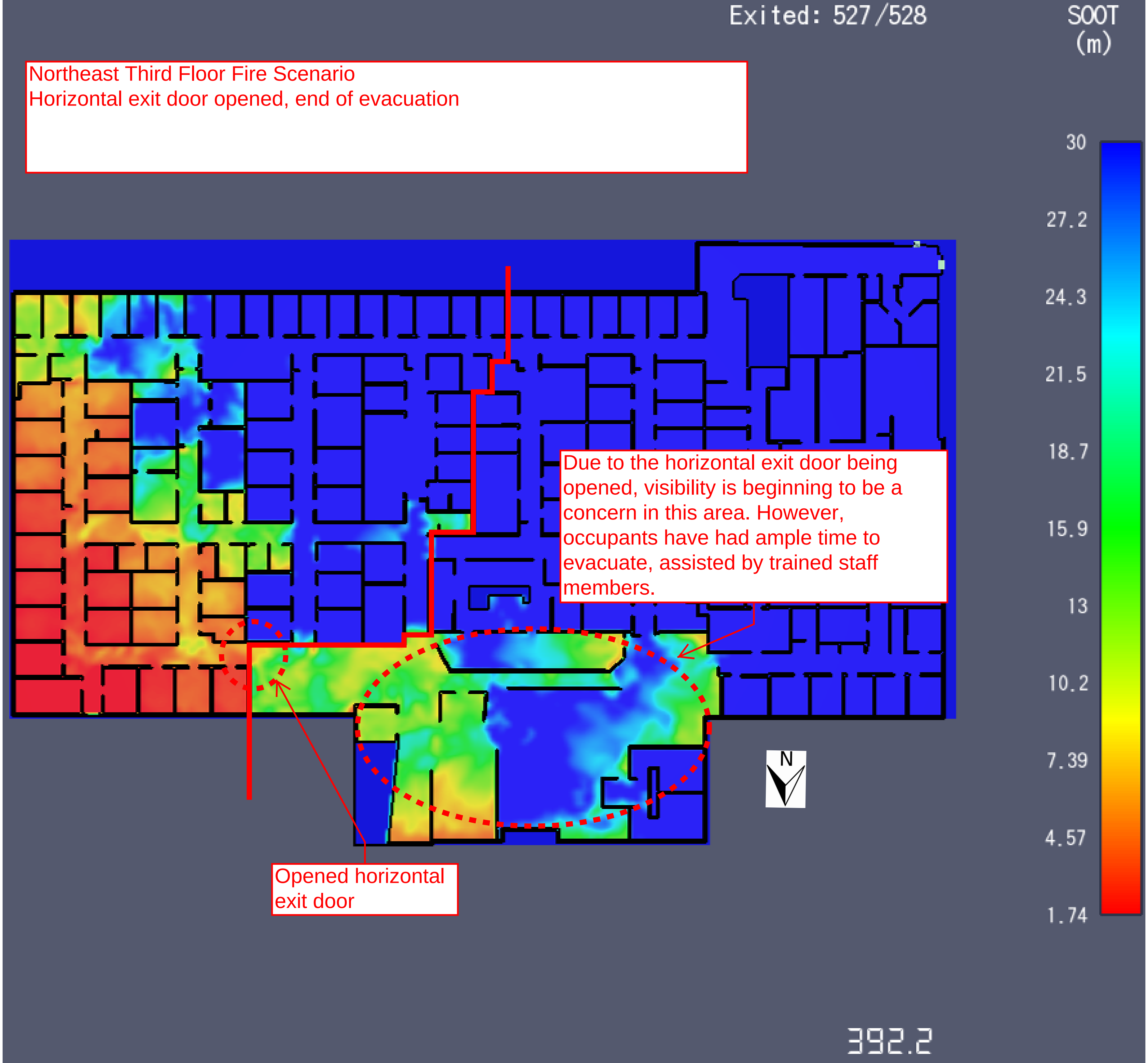

Exited: 203 /528
SOOT
(m)
Northeast Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
30
27.2
24.3
21.5
18.7
15.9
13
10.2
7.39
4.57
1.74
Occupants should not be experiencing visibility problems
Opened horizontal exit door
N
133.6



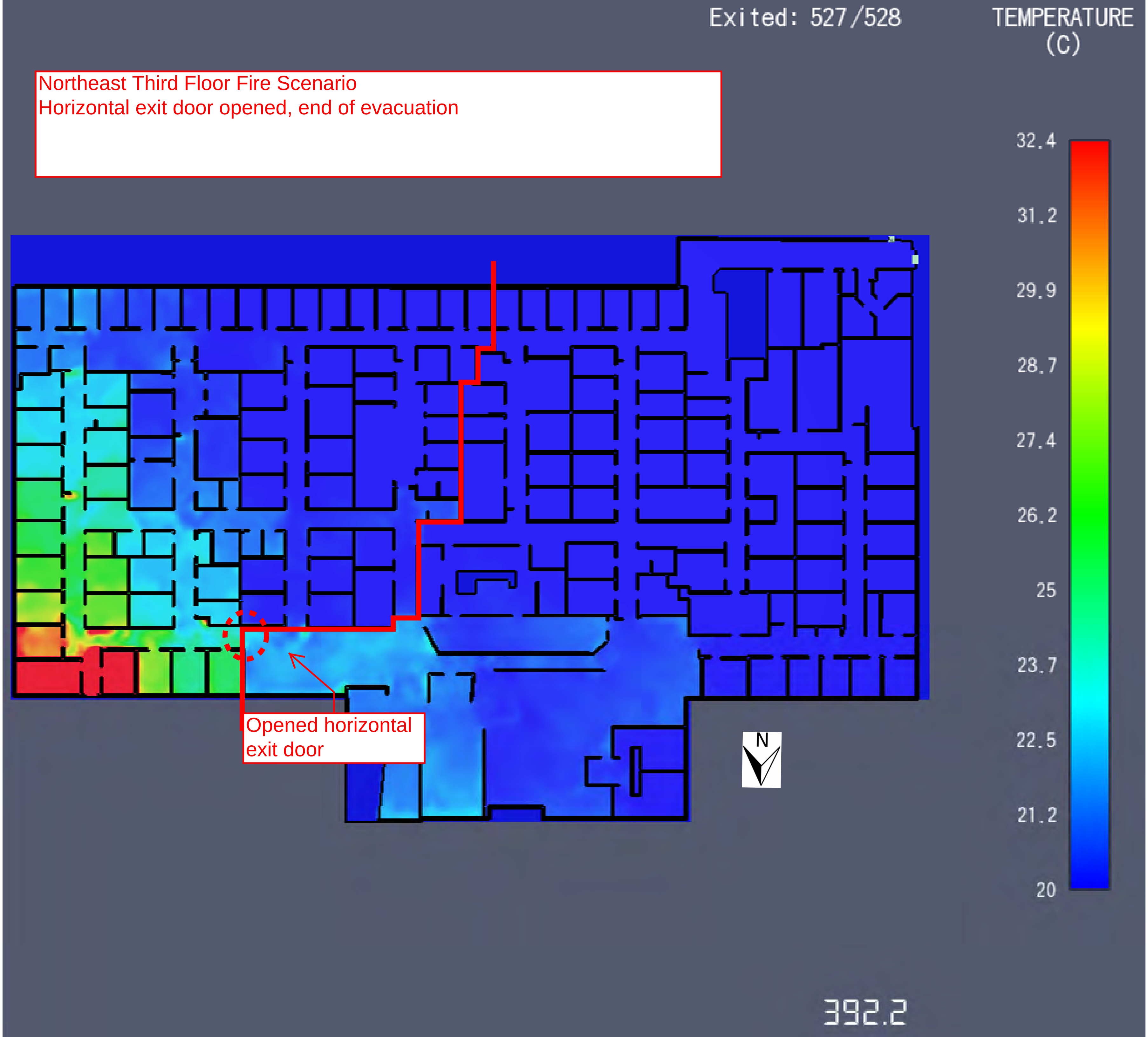
Exited: 203/528
TEMPERATURE (C)
Northeast Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
32.4
31.2
29.9
28.7
27.4
26.2
25
23.7
22.5
21.2
20
Opened horizontal exit door
N
133.6

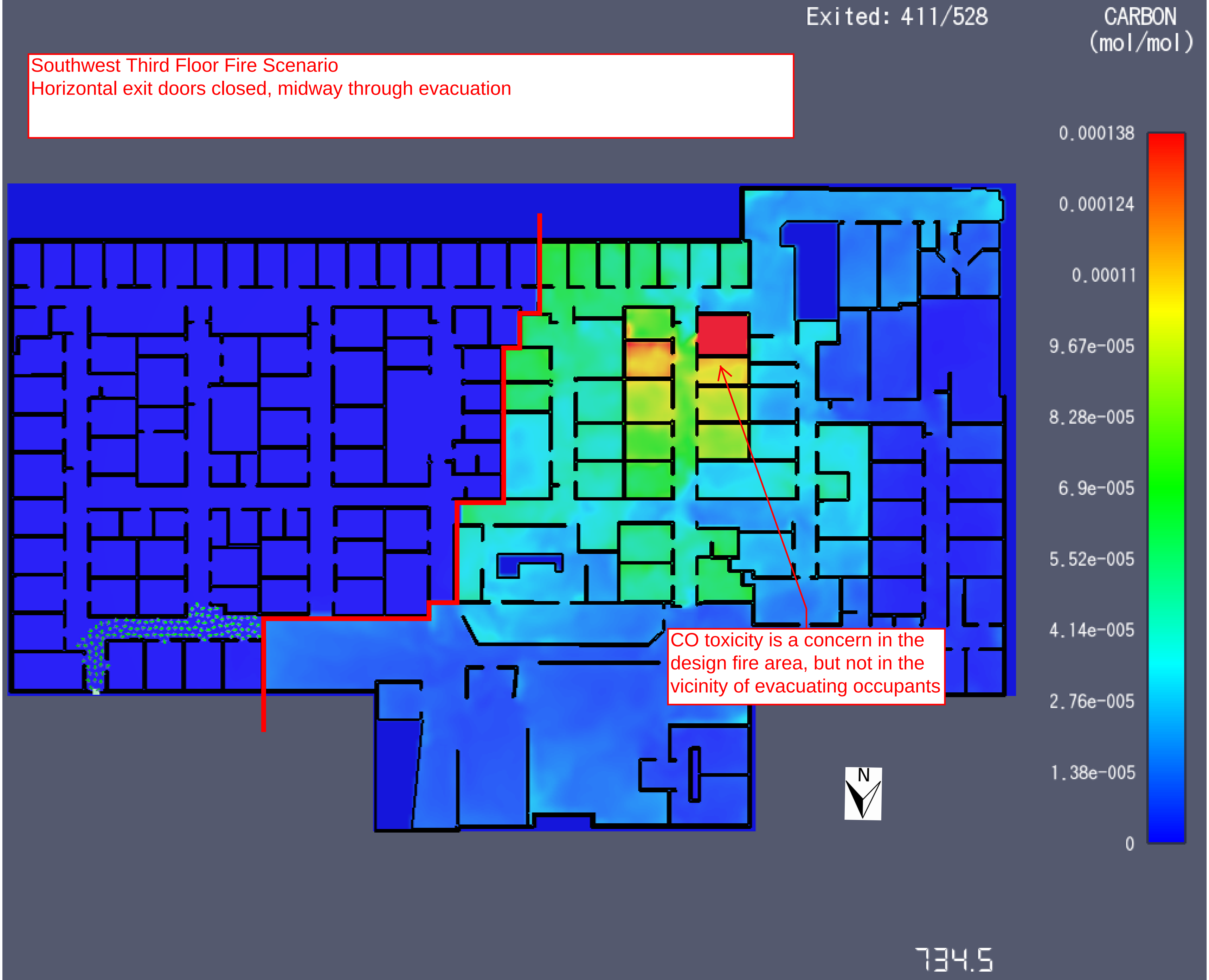


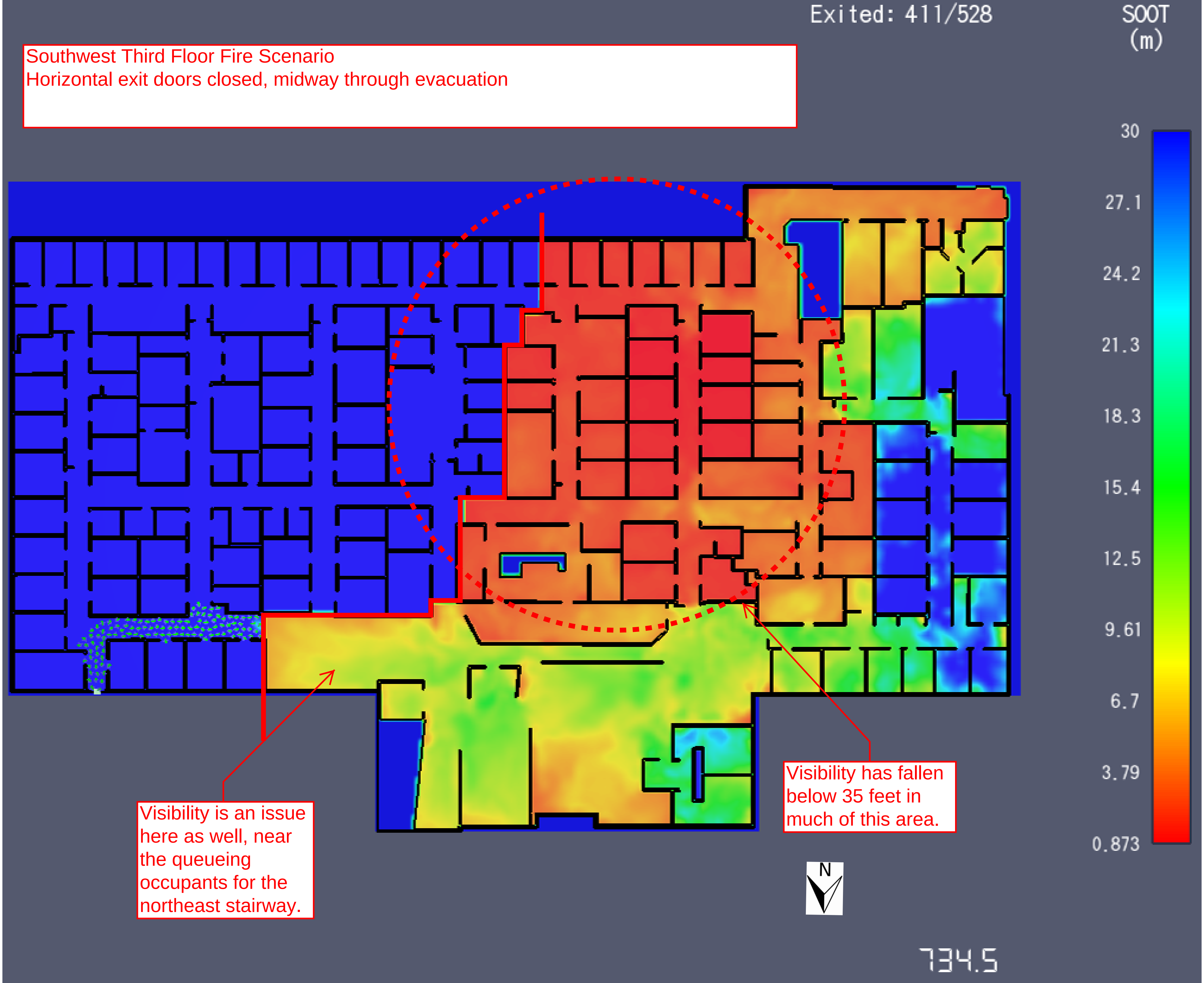
Exited: 527/528
CARBON (mol/mol)
Northeast Third Floor Fire Scenario
Horizontal exit door opened, end of evacuation
7.32e-005
6.59e-005
5.86e-005
5.12e-005
4.39e-005
3.66e-005
2.93e-005
2.2e-005
1.46e-005
7.32e-006
0
CO concentrations are only concerning near the design fire
Occupants are predicted to have fully evacuated by this time
Opened horizontal exit door
N
392.2



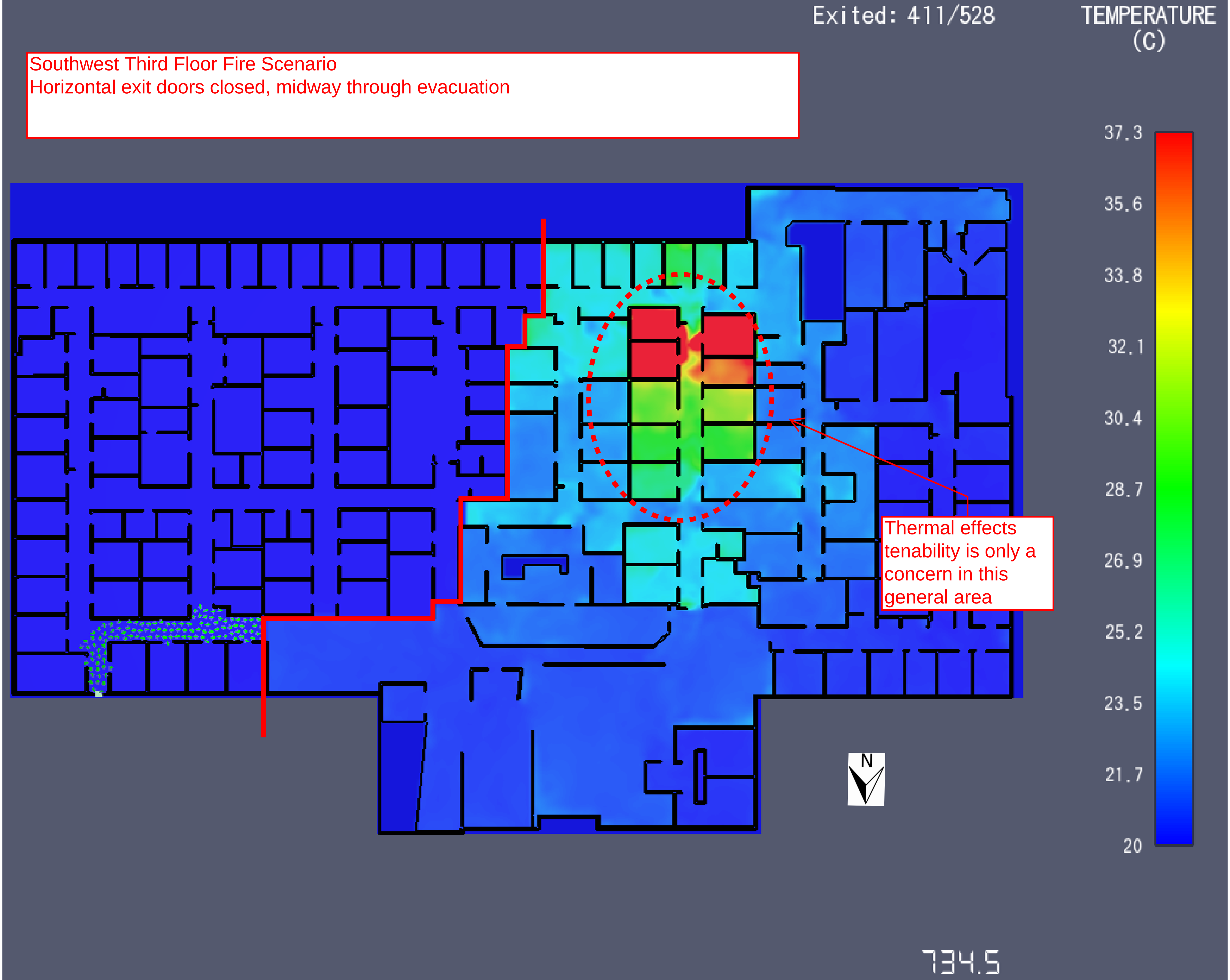
Exited: 527/528
SOOT
(m)
Northeast Third Floor Fire Scenario
Horizontal exit door opened, end of evacuation
30
27.2
24.3
21.5
18.7
15.9
13
10.2
7.39
4.57
1.74
Due to the horizontal exit door being opened, visibility is beginning to be a concern in this area. However, occupants have had ample time to evacuate, assisted by trained staff members.
N
Opened horizontal exit door
392.2


Exited: 527/528
TEMPERATURE (C)
Northeast Third Floor Fire Scenario
Horizontal exit door opened, end of evacuation
32.4
31.2
29.9
28.7
27.4
26.2
25
23.7
22.5
21.2
20
Opened horizontal exit door
N
392.2


Exited: 411/528
CARBON
(mol/mol)
Southwest Third Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
0.000138
0.000124
0.00011
9.67e-005
8.28e-005
6.9e-005
5.52e-005
4.14e-005
2.76e-005
1.38e-005
0
CO toxicity is a concern in the design fire area, but not in the vicinity of evacuating occupants
N
734.5

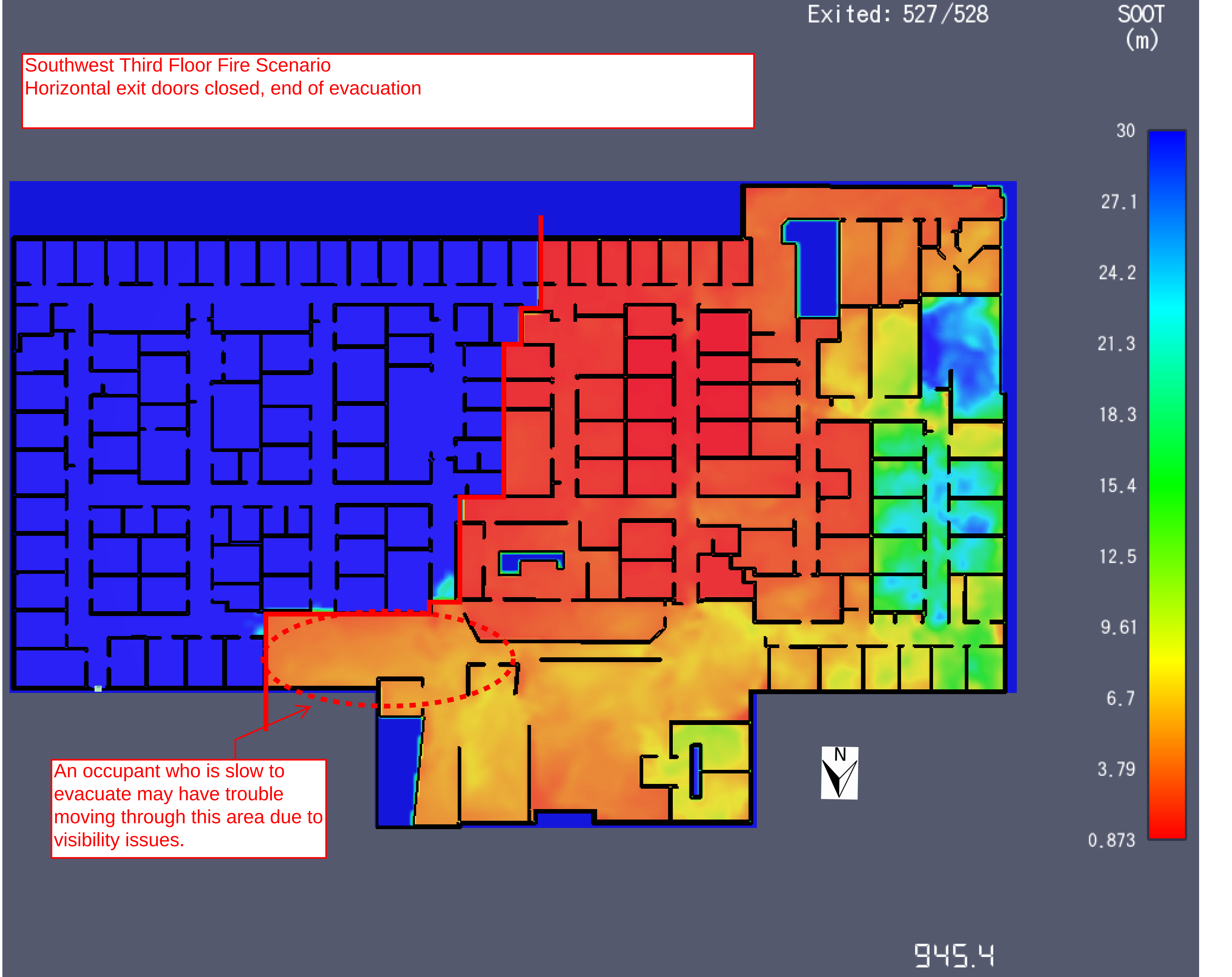


Exited: 411/528
SOOT (m)
Southwest Third Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
30
27.1
24.2
21.3
18.3
15.4
12.5
9.61
6.7
3.79
0.873
Visibility is an issue here as well, near the queueing occupants for the northeast stairway.
Visibility has fallen below 35 feet in much of this area.
N
734.5

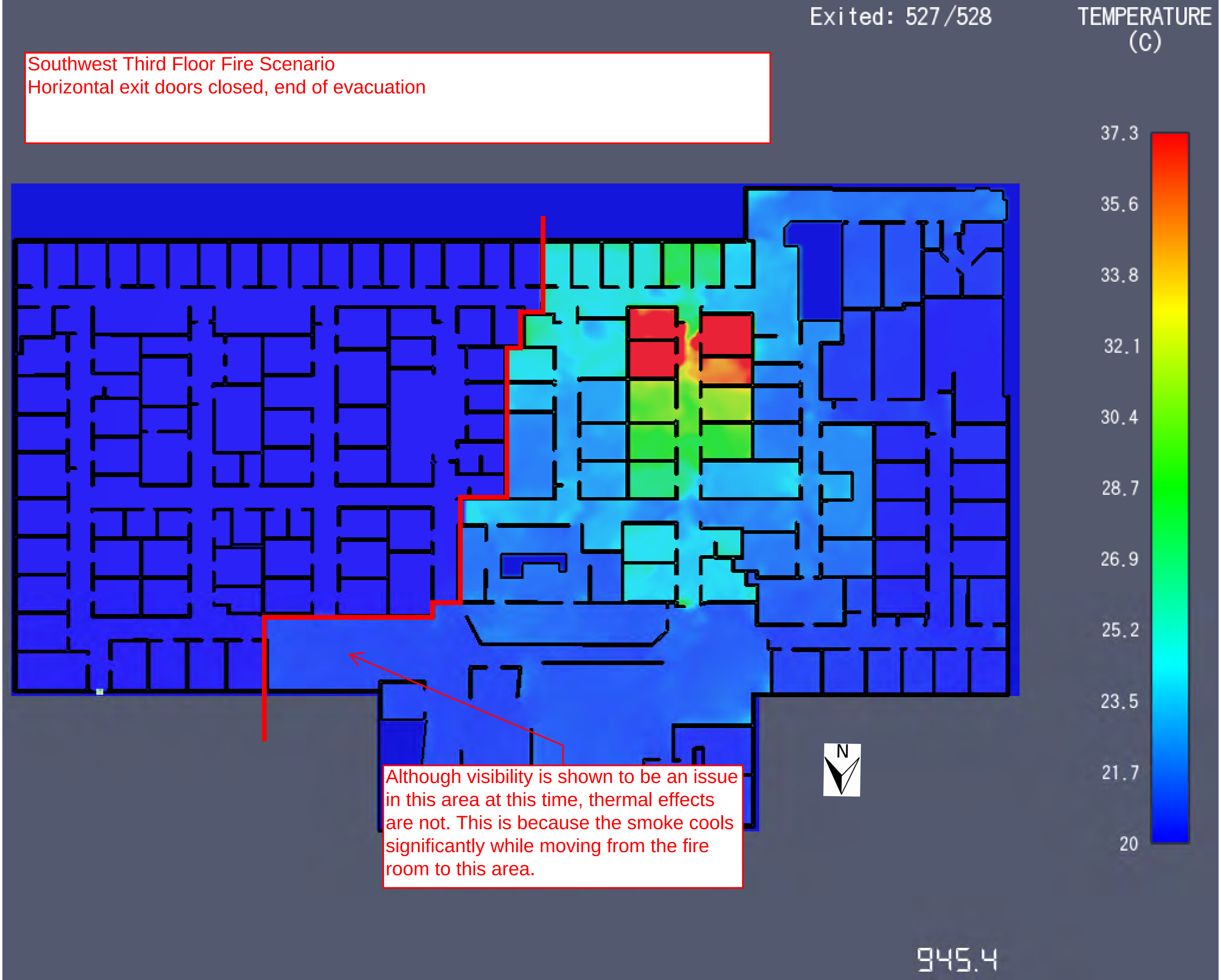


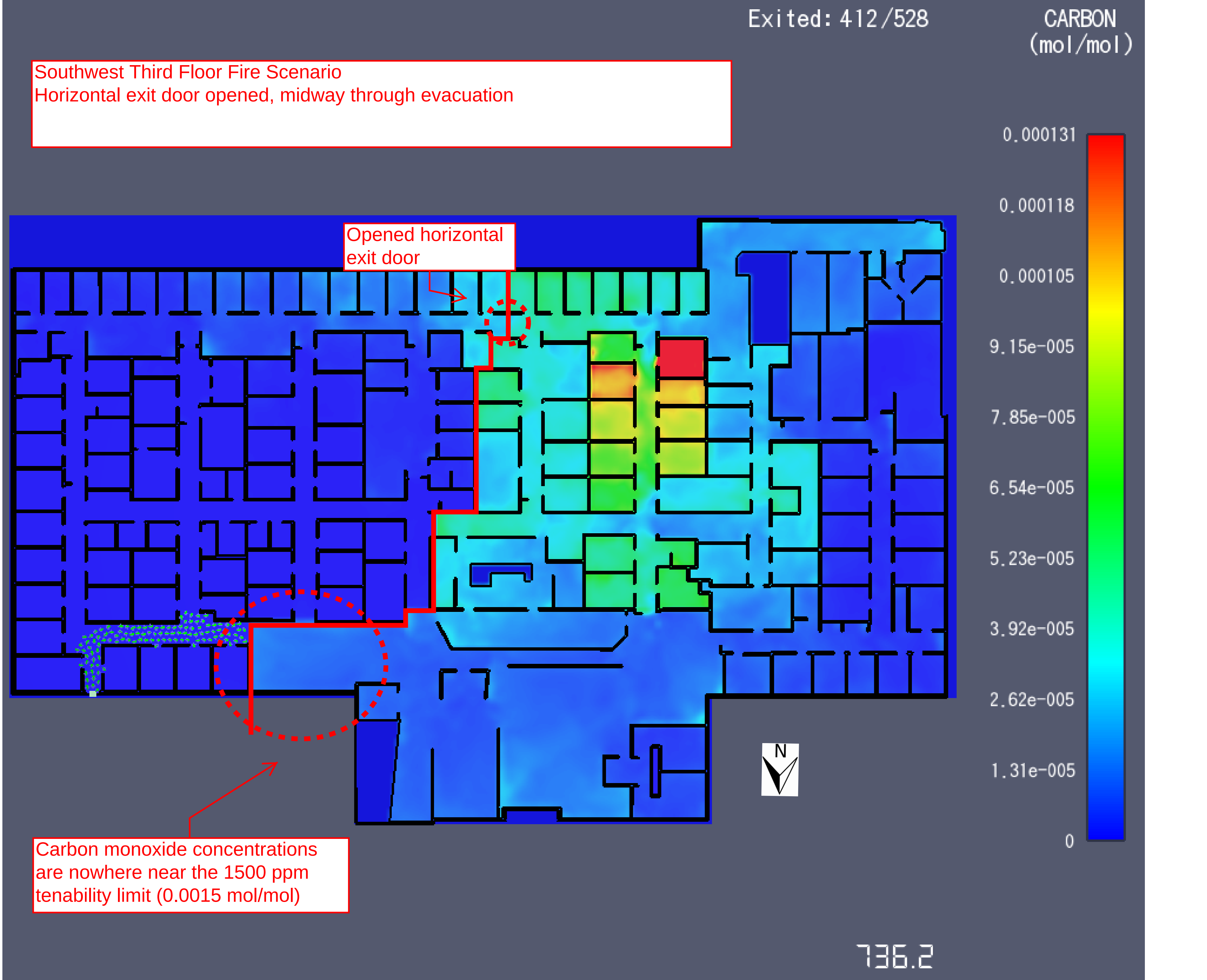
Exited: 411/528
TEMPERATURE (C)
Southwest Third Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation
37.3
35.6
33.8
32.1
30.4
28.7
26.9
25.2
23.5
21.7
20
Thermal effects tenability is only a concern in this general area
N
734.5


Exited: 527/528
CARBON (mol/mol)
Southwest Third Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
The queueing occupants have completely evacuated before CO toxicity is an issue in the immediate area.
0.000138
0.000124
0.00011
9.67e-005
8.28e-005
6.9e-005
5.52e-005
4.14e-005
2.76e-005
1.38e-005
0
N
945.4

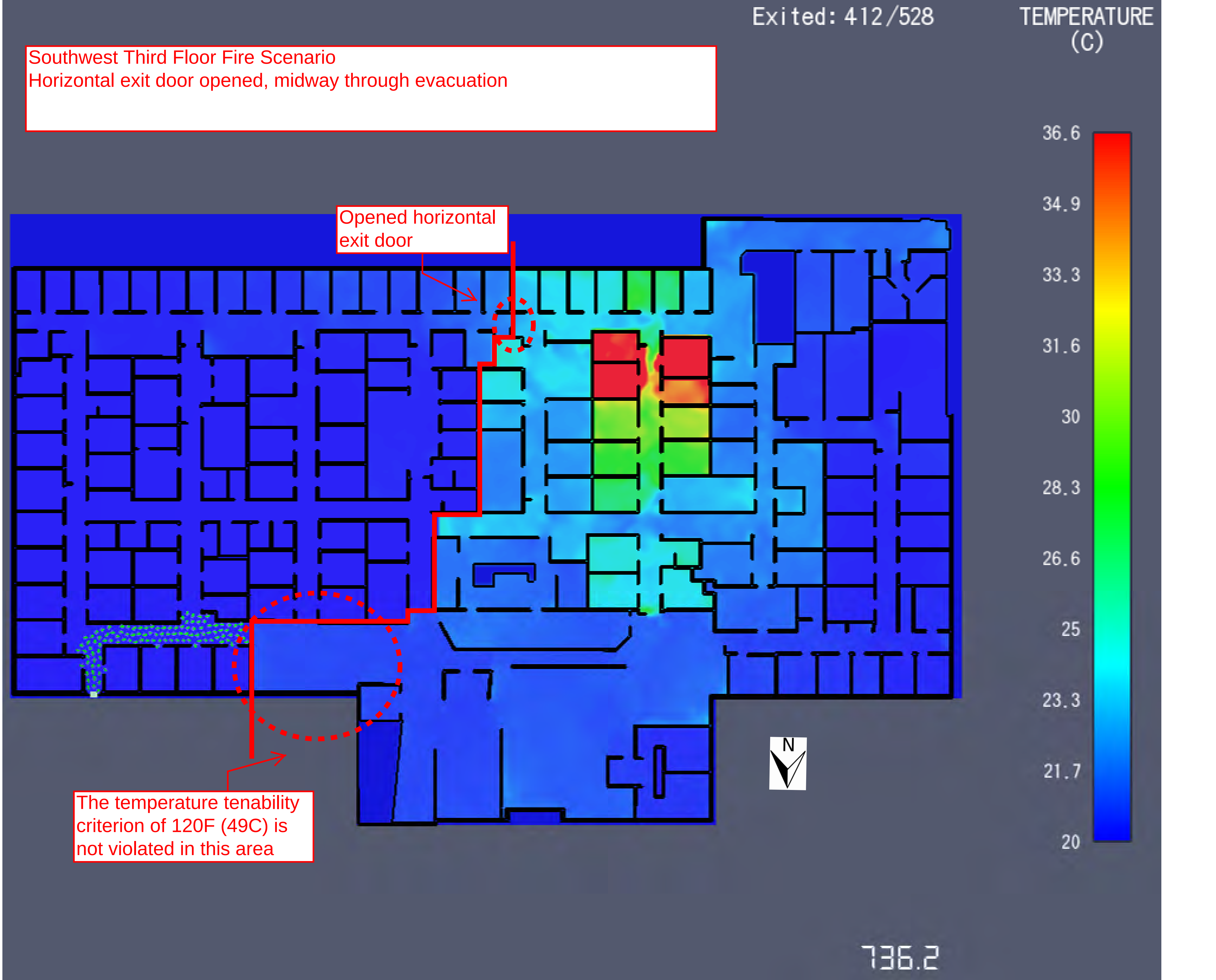


Exited: 527/528
SOOT
(m)
Southwest Third Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
30
27.1
24.2
21.3
18.3
15.4
12.5
9.61
6.7
3.79
0.873
N
An occupant who is slow to evacuate may have trouble moving through this area due to visibility issues.
945.4

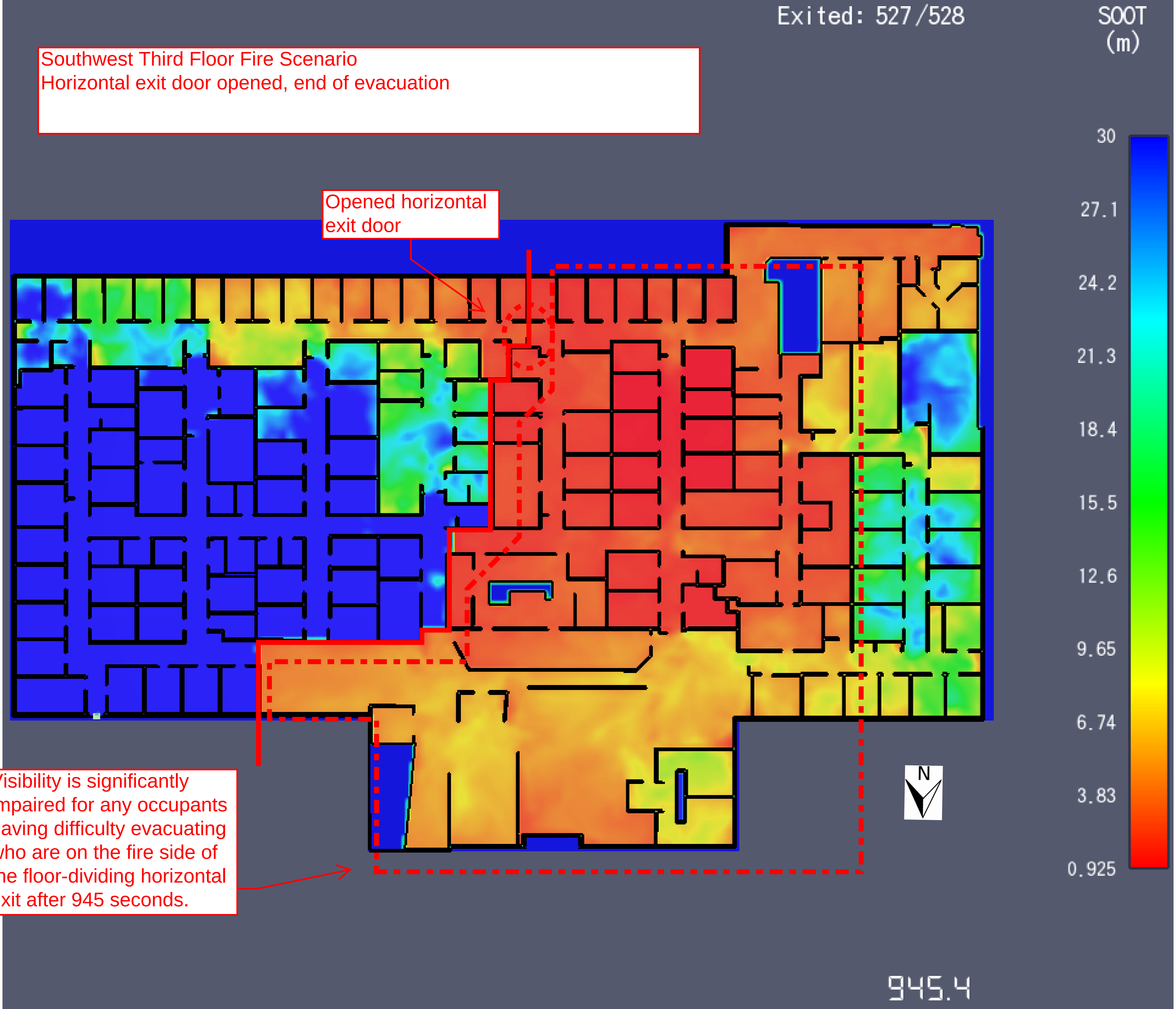

Exited: 527/528
TEMPERATURE (C)
37.3
35.6
33.8
32.1
30.4
28.7
26.9
25.2
23.5
21.7
20
Southwest Third Floor Fire Scenario
Horizontal exit doors closed, end of evacuation
Although visibility is shown to be an issue in this area at this time, thermal effects are not. This is because the smoke cools significantly while moving from the fire room to this area.
N
945.4

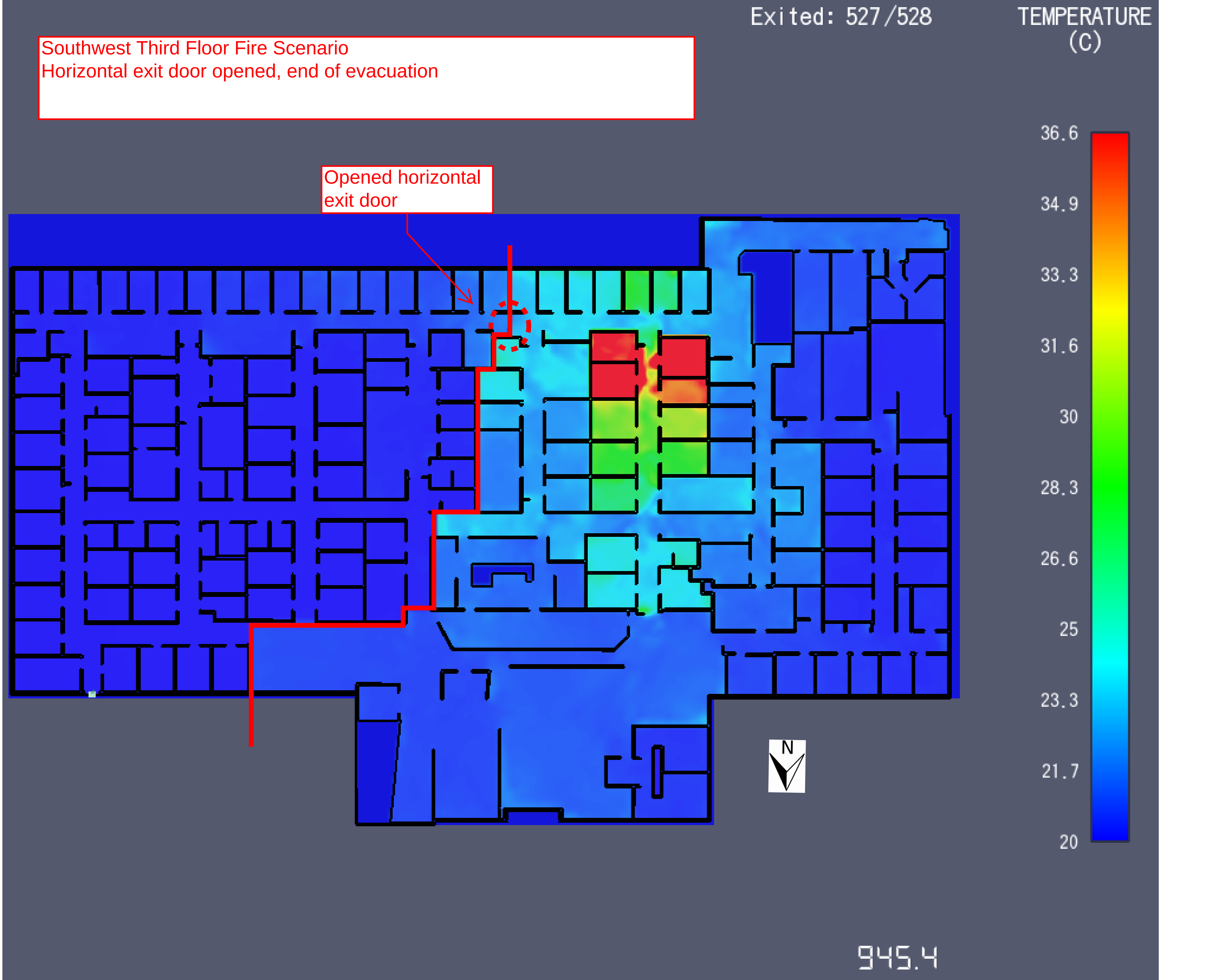

Exited: 412/528
CARBON
(mol/mol)
Southwest Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
Opened horizontal
exit door
0.000131
0.000118
0.000105
9.15e-005
7.85e-005
6.54e-005
5.23e-005
3.92e-005
2.62e-005
1.31e-005
0
N
Carbon monoxide concentrations
are nowhere near the 1500 ppm
tenability limit (0.0015 mol/mol)
736.2

Exited: 412/528
SOOT (m)
Southwest Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
Opened horizontal exit door
Visibility falls below 35 feet in some areas on the "egress side" of the floor-dividing horizontal exit.
Visibility fell below 35 feet in this area, while occupants are queueing for the northeast stairway.
30
27.1
24.2
21.3
18.4
15.5
12.6
9.65
6.74
3.83
0.925
N
736.2


Exited: 412/528
TEMPERATURE (C)
Southwest Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation
Opened horizontal exit door
The temperature tenability criterion of 120F (49C) is not violated in this area
36.6
34.9
33.3
31.6
30
28.3
26.6
25
23.3
21.7
20
N
736.2


Exited: 527/528
CARBON (mol/mol)
Southwest Third Floor Fire Scenario
Horizontal exit door opened, end of evacuation
Opened horizontal exit door
Occupants should have fully evacuating before the CO toxicity criterion of 1500 ppm (0.0015 mol/mol) is violated.
0.000131
0.000118
0.000105
9.15e-005
7.85e-005
6.54e-005
5.23e-005
3.92e-005
2.62e-005
1.31e-005
0
N
945.4


Exited: 527/528
SOOT
(m)
Southwest Third Floor Fire Scenario
Horizontal exit door opened, end of evacuation
Opened horizontal exit door
30
27.1
24.2
21.3
18.4
15.5
12.6
9.65
6.74
3.83
0.925
N
Visibility is significantly impaired for any occupants having difficulty evacuating who are on the fire side of the floor-dividing horizontal exit after 945 seconds.
945.4


Southwest Third Floor Fire Scenario
Horizontal exit door opened, end of evacuation
Exited: 527/528
TEMPERATURE
(C)
36.6
34.9
33.3
31.6
30
28.3
26.6
25
23.3
21.7
20
Opened horizontal exit door
N
945.4